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ABSTRACT

The Science in Action series is designed to teach practical science concepts to special-needs students. It is intended to develop students' problem-solving skills by teaching them to observe, record, analyze, conclude, and predict. This document contains a student workbook which deals with basic principles of physical science. Seven separate units include: (1) making work easy; (2) the inclined plane; (3) the wedge; (4) the lever; (5) the wheel and axle; (6) the pulley; and (7) using machines. The units consist of basic introductory information and questions, worksheets, a self-checking quiz, and instructions for experiments. A cumulative test is provided at the end of the workbook, along with a glossary. The teachers guide (which is included) explains how to use the workbook, together with teaching suggestions and enrichment activities for each unit. (TW)

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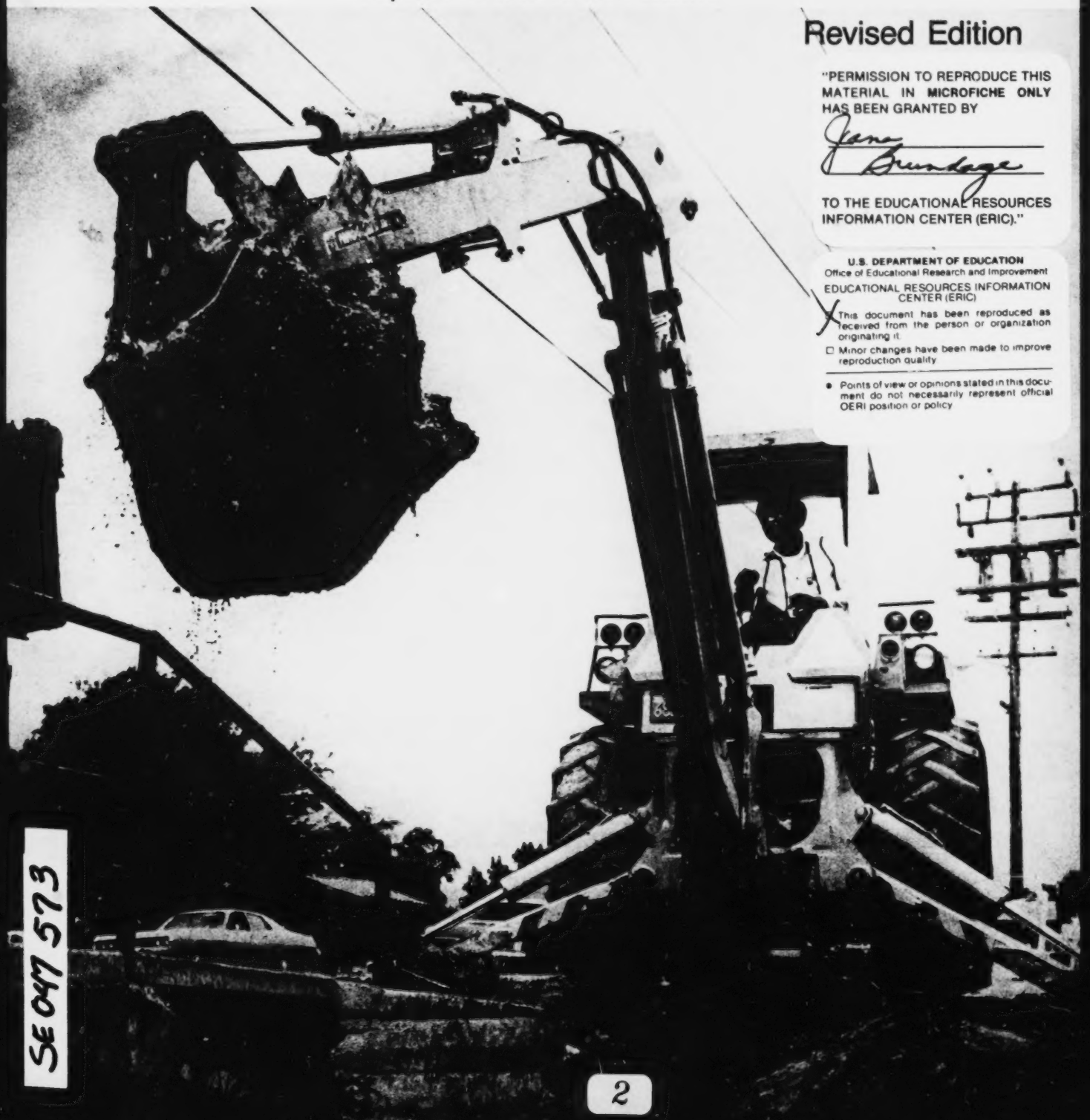
Machines

Physical Science in Action



Revised Edition

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Machines Revised Edition

Science in Action

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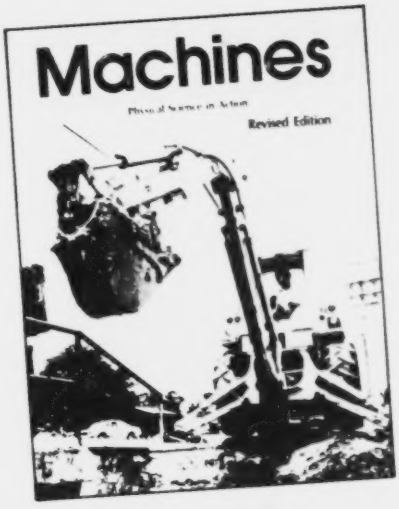

Teacher's Manual

Machines Revised Edition

Susan D. Echaore and Budd Wentz

A Janus **Physical Science in Action** Book

Teacher's Manual written by Susan D. Echaore

OVERVIEW

Using Science

How many of your special-needs students think they actually use science in their lives? Probably very few of them. But after completing ***Machines,*** a Janus ***Science in Action*** workbook, your students can see how they do use science every day.

Machines is written for the older adolescent with learning and reading problems. Through easy-to-understand explanations and fun, hands-on activities and experiments, students learn some basic physics principles about machines. Students also learn how to apply their new knowledge to work situations they may have now or in the future.

Designed for Special Students

This workbook can fit the skills of any special-needs student. Concepts are broken down into short, easy lessons, each followed by an activity or experiment to reinforce the learning. You can easily expand or adapt lessons to fit the different skills of your students. Additional suggested activities at the end of each unit are multi-modal, so all your students can successfully complete at least one.

Machines is one of a set of Janus *Physical Science in Action* workbooks. (Other Janus sets are ***Life Science in Action*** and ***Earth Science in Action***.) You can use *Machines* as a supplement to or as the core of your science program. You'll find that it can help your students meet general science and laboratory science requirements.

OBJECTIVES OF THIS WORKBOOK

The Janus *Science in Action* series helps special-needs students learn basic and practical science concepts they can apply to daily living. The series also helps students develop problem-solving and thinking skills by teaching them to observe, record, analyze, conclude, and predict.

The objectives of *Machines* are:

- The student will learn about these simple machines and what they do: inclined plane, wedge, lever, wheel and axle, and pulley.
- The student will learn that all machines are made up of one or more simple machines.
- The student will gain a basic understanding of how machines make work easier.
- The student will learn a basic vocabulary that describes machines and how they work.
- The student will be able to apply his or her learning to everyday situations.

READABILITY

The average reading level of *Machines* is below 2.5, according to the revised Spache Readability Formula. Target words that are particularly useful for understanding concepts are listed and defined in a glossary at the end of the book. Those words are set in boldface type when they first appear in the text. They are also listed under "Teaching the Units" in this manual.

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HOW TO USE THIS WORKBOOK

The Workbook Format

Machines is fomatted so students can recognize what to do on each page as they work through the book.

Units 1 through 6 open with a brief introduction and topic questions, which focus students on the concepts they'll be learning in the unit. The introductory page also includes a short vocabulary exercise, "Before You Start."

The units are divided into one-and two-page lessons; each lesson is followed by an activity or experiment. The final lesson in those units, "Machine Choice," presents situations in which students apply their learning and decide what machine would be best to complete the job.

Units 1 through 6 end with "Check Yourself," a comprehension exercise, and "Check These Out," a list of activities that expand the concepts taught in a unit.

In unit 7, written activities are designed so that students apply their learning from units 1 through 6.

Introducing the Book

Try something different. Take your students on a field trip to a place where machines are in use. You might take students to places such as a factory, a shipyard, or a construction site. Tell them to observe what kinds of machines they see and what kinds of work the machines do.

In class, discuss their observations. Then distribute the workbook. Give them time to leaf through the book; comment on some of the activities or experiments they'll do. Finally, read the introduction.

Introducing the Unit

You might bring in machines that incorporate the simple machine students will learn about. Demonstrate what those machines do. Discuss what kinds of work the machines are used for. Then have students guess how the machines make work easy. Write down their answers and post them in class. When they finish the unit, have them compare their guesses with what they learned.

Before students begin a unit, make sure they understand the target words. You might reinforce the "Before You Start" exercise with your own vocabulary exercises and word games.

Teaching Suggestions

Getting Yourself Ready

Before students begin working on *Machines*, familiarize yourself with the concepts being taught. The bibliography at the end of this manual lists some books that can quickly give you a general knowledge of machines. Consult shop teachers, science teachers, local inventors, auto mechanics, construction workers, and so on who can explain information to you as well as be guest speakers for your class.

Read each unit yourself before assigning it to your students. Answer the questions and do the activities and experiments to know what kinds of problems may arise. You may need to adjust some activities to fit the skills of your students.

Have a variety of bonus activities on hand for those students who finish a lesson early. Make sure activities match the different skills of your students. Plan enrichment activities that take students out into the community, so they can see how science is a part of their lives.

Helping Your Students Succeed

We suggest you keep students together as they work through *Machines*. Help them each succeed at their own skill level. Pace their learning: Begin all your students on a lesson at the same time. Make sure they understand the concept before they work on an activity or experiment. Encourage questions and discussions. (You might make a "Question Wall": Use a bulletin board or tape butcher paper on a wall. Write down questions students ask, and allow them to write their answers on the wall.)

Demonstrate an activity or experiment before students do it. Help them reach the correct conclusions. Direct your faster students to enrichment activities as you work with your slower students.

End-of-the-Book Exercises

Machines ends with "Show What You Learned," a page of two brief comprehensive tests. "What's the Answer?" tests understanding of major concepts; "What's the Word?" tests knowledge of some target words.

About the Glossary

The glossary at the end of the workbook lists and defines the target words. Words are listed in alphabetical order and divided into syllables to help students decode. Target words are defined specifically to fit the context of the science concepts taught in *Machines*.

TEACHING THE UNITS

Unit 1: Making Work Easy

Target Words: *force, simple machine, tool, work*

Unit 1 introduces this principle: *Work is done when a force moves something from one place to another.* Make sure your students understand work in this context before they study later units.

PAGE 5: **Doing Work**

Students learn that to do work they must push or pull something over a distance. The push or pull is the force that's used to move something. To compare work and non-work, ask: *Are you doing work when you push with all your strength against a wall?* (Answer: No; to do work, the wall must move.)

PAGE 6: **Machines**

Students learn that a machine is anything that can help them do work. They learn that common hand tools are machines. Bring in hand tools and ask students how each machine helps them do work.

You might expand this lesson by teaching students that machines need some kind of power in order to work. List different machines and ask students what kind of power makes each machine work.

Both the crane and shovel help workers dig and lift dirt more easily.

PAGE 7: **Simple Machines**

Students learn that every machine is made up of at least one simple machine. Explain that simple machines are the most basic machines. They can be made of simple things such as rocks, branches, string, and ball bearings (marbles).

Students learn the names of five simple machines: inclined plane, wedge, lever, wheel and axle, and pulley. (Some references include the screw as a simple machine; others consider it to be a kind of inclined plane.)

PAGE 8: **Check Yourself**

Across **1.** push **4.** less **5.** force **7.** machines *Down* **2.** simple machines **3.** work **6.** tools **7.** more

Enrichment Activities

- Play "Machine Charade." One student pantomimes a machine and the others guess what it is.
- Machines can be thought of as extensions of the body. For instance, a shovel is like a hand that digs up dirt. Show pictures of machines and ask students how they are extensions of the body.

Unit 2: The Inclined Plane

Target Words: *inclined plane, ramp, slope, steep*

This unit teaches students that an inclined plane can help them move something to a high place with less force.

PAGE 10: **Ramps**

Students learn that an inclined plane is a slope connecting a low place to a high place; and that moving objects up the slope makes work easier.

You might expand the lesson by teaching this principle: *When you change the direction of the force, you can make work easier.* Help students conclude that with an inclined plane they push or pull something up a slope instead of lifting it straight up.

PAGE 11: **How Much Force?**

Materials: *a 1-foot long board, two thick books (such as desk dictionaries), heavy coffee cup, thin rubber band*

Students compare doing the same work with and without an inclined plane. Make sure they understand that the stretch of the rubber band shows how much force is used. The longer the rubber band stretches, the more force is used.

You use less force when you slide the cup up a ramp.

PAGES 12–13: **Experiment 1—What kind of inclined plane makes work easier?**

Materials: *same coffee cup with rubber band tied to its handle as used on page 11, a ruler (with a hole in it), twelve thick books (such as desk dictionaries), a 1-foot long board, a 3-foot long board*

Students build a short and a long ramp and discover that the long ramp makes work easier. Help students see that the short ramp has a steeper slope. Then help them conclude that work is easier using the long ramp because the slope is not so steep.

You might expand their learning by explaining this principle: *When you move an object over a longer distance, you make work easier.*

Observations: **1.** the short board **2.** on the long ramp

Conclusions: **1.** moving things up a slope that's very steep **2.** moving things up a less steep slope **3.** a long ramp

PAGE 14: **Machine Choice**

Students apply what they learned and choose the best inclined plane to do work.

Answers: **1.** Picture B. (Wording may vary.) Ramp B has a slope that's less steep, so you use less force moving things up that ramp. **2.** Walk up the cement path. (Wording may vary.) The path doesn't have as steep of a slope.

PAGE 15: **Check Yourself**

1. a. easier. **2. a.** a low place to a high place. **3. c.** lift things. **4. b.** more force. **5.** The other inclined plane is the truck ramp.

Enrichment Activities

- As a class project, build a ramp for the handicapped at one entrance of your school.
- Have students make a diorama of ancient Egyptians building a pyramid. Be sure to include ramps.

Unit 3: The Wedge

Target Words: *concentrate, split, wedge*

This unit teaches students that a wedge helps them push two objects apart with less force.

PAGE 17: **Pushing Things Apart**

Students learn that because of its triangular shape, the wedge can push objects apart. They also learn that wedges are part of tools that cut and split things. Wedges, such as doorstops, can also lift heavy objects and hold them in place. Wedges can hold doors and windows in place, and wobbly legs of heavy furniture and appliances.

PAGE 18: **Wedges Make You Stronger**

Materials: *a wedge (such as a doorstop), two unopened soup cans, a book, masking tape*

Students find that a wedge helps split things apart. Explain that the force they use trying to pull the cans apart is the same force they use pushing down on the wedge. The wedge concentrates the force in one spot and splits the cans apart.

The wedge further reinforces this principle: *When you change the direction of the force, you can make work easier.* Help students conclude that a wedge helps them split an object apart by pushing down instead of pulling apart.

PAGE 19: **Different Shapes**

Students learn that wedges have different shapes to do different jobs. Different wedges help them cut, split, or make holes. **1.** cuts **2.** cuts **3.** makes holes **4.** splits apart **5.** splits apart

PAGE 20: **Machine Choice**

Students apply what they learned and choose the best wedge for different jobs.

PAGE 21: **Check Yourself**

1. b. is like a triangle. **2. a.** cut things. **b.** split things. **c.** make holes. **3. b.** concentrate your force. **4. a.** large and small machines. **b.** tools. **5.** The other wedge is the scissors.

Enrichment Activities

- Bring in different tools with wedges. Ask students what kinds of work each wedge does.
- Have students find out what kinds of wedges Native American tribes in your area used. Then have students make models of them with clay and cardboard.
- Give students each a piece of balsa wood and a push pin. Have them figure out how to split the wood with the pin.

Unit 4: The Lever

Target Words: *fulcrum, increase, lever, object*

Students learn that a lever helps them lift heavy objects and loosen tight objects with less force.

PAGE 23: **Getting Stronger**

Students learn that a lever increases force so that they become stronger. A lever has two ends: One holds the object to be moved; the other is where force is applied. The lever rests against a fulcrum. (A fulcrum can be anywhere on a lever.) As force is applied to one end, the other end moves the object with a greater force.

You might expand this lesson by teaching the three classes of levers. (For details, look up levers in an encyclopedia.) Bring in examples of each class. Make sure students understand where the fulcrum is in each kind of lever.

PAGES 24-25: **Experiment 2—Which makes you stronger: a short or a long lever?**

Materials: *three boards (2 feet, 4 feet, and 6 feet long), a desk dictionary*

Students compare three lengths of levers. They discover that a longer lever makes it easier to lift things. Remind students to place the fulcrum in each lever one foot from the end that the partner stands on. (Boards should be able to support the heaviest person in class; you might use 2x10 boards.)

The lever further reinforces this principle: *When you move an object over a longer distance, you can make work easier.* Help students conclude that the "longer distance" on a lever is the length between the fulcrum and the end they push down on.

Observations: 1. Answers may vary. **2.** the longest lever **3.** the shortest lever

Conclusions: 1. a long lever **2.** a long lever

PAGE 26: **Where Do You Put the Fulcrum?**

Materials: *a desk dictionary, a 6-foot long board*

Students move the fulcrum to three different points on a lever. Help them conclude that the closer the fulcrum is to their partner, the less force they use. (Wording may vary.) **2.** I can't lift my partner. **3.** Answers may vary. **4.** I can lift my partner. Put the fulcrum near that object.

PAGE 27: **Machine Choice**

Students apply what they learned and choose the best lever for the job. Help them conclude that the best choice is the long branch, and the fulcrum should be as close as possible to the rock.

PAGE 28: **Check Yourself**

1. a. lift heavy objects. **b.** move objects that are stuck. **2. b.** the place that a lever turns about. **3. a.** use less force to lift it. **4.** The other levers are the wheelbarrow and shovel.

Enrichment Activities

- "Prove It's a Lever!": Students choose a machine or part of a machine and explain why it is a lever.
- Have students make puppets with moveable arms and legs. Have them explain how the limbs are levers.

Unit 5: The Wheel and Axle

Target Words: *control, gear, wheel and axle*

Students learn that the wheel and axle help them move things with less force.

PAGE 30: **Moving in Circles**

Help students understand that a wheel and axle is a simple machine only when the two parts are rigidly attached to each other and that moving one part makes the other part also move. (Wheels that spin around stationary axles are not simple machines. For

example, wheels and axles on skates, rolling carts, and office chairs are not simple machines because the wheels turn independently around the axles.)

A simple machine gives users a mechanical advantage: it enables them to move something heavy while exerting relatively little force. The wheel and axle is a kind of lever that moves in a circle, thus greatly enhancing the force applied and enabling the user to move something with greater ease.

PAGE 31: **Increases Our Force**

This lesson reinforces how a wheel and axle increases force in order to move objects. The lesson presents examples of wheels and axles that do not look like wheels. Help students conclude that a wheel and axle does not need to look like a wheel, but need *only* move like a wheel. Help them also conclude that the wheel and axle must be connected and that the parts turn together.

The lesson ends with students using a wheel and axle (jar opener) to help them open a jar more easily. Point out the wheel and axle: the wheel is the handle; the axle is the part that fits securely on the jar lid together with the lid itself.

You might bring in examples of wheels and axles, such as wrenches and screwdrivers, for students to manipulate. Have them point out the wheel and axle on a machine by showing which parts are making the large and small circles.

PAGE 32: **Another Kind of Wheel and Axle**

Materials: *two bottle caps from soda bottles, two push pins, a hammer, a block of soft wood (such as pine)*

Students learn how a gear turns another gear. Make sure students understand that gears are a kind of wheel and axle. They are attached to moving parts in machines. If you have an old watch with hands, you might take off its cover to show students the gears inside.

PAGE 33: **A Close Look at Gears**

Materials: *an eggbeater, a pint of whipping cream (or four egg whites), two bowls, a fork, a watch*

Students discover how gears control the speed of moving parts in machines. Try to bring in at least one old-fashioned eggbeater for students to see all gears turning each other. The modern eggbeaters have a covering so that the small gears are hard to see.

Here's an opportunity to show students the progress of more efficient machines doing the same job. Bring in as many of the following as possible: fork, egg whisk, eggbeater, electric mixer, blender, and Cuisinart. Give different students a machine, then have them begin whipping up cream at the same time. Compare how long each machine takes to whip the cream.

PAGE 34: **Machine Choice**

Students examine a hand-turned pencil sharpener to see how a wheel and axle accomplishes work. Point out to them that another simple machine, the wedge, does the actual sharpening. The wheel and axle moves the cutting wedges against the pencil. **1.** When you turn the handle, the pencil holder and cutting rollers move. **2.** The handle is the wheel. It moves in a circle, like a wheel. **3.** The pencil holder is the axle. It is connected to the center of the wheel, and it turns when the wheel turns. **4.** The cutting rollers are attached to the pencil holder (the axle), so they move when it moves. **5.** The gears push against the rollers and cause the rollers to spin. **6.** When you turn the handle, the pencil holder also turns. That causes the cutting rollers to move around a circle. As the cutting rollers move, gears push against them and cause them to spin. The sharp edges of the cutting rollers then cut into the pencil and sharpen it.

PAGE 35: **Check Yourself**

(Wording may vary.) **1.** Move things over long distances. **2.** It increases your force. **3.** The shape of its teeth. **4.** To control how fast or slow a part moves in a machine. **5.** The other wheels and axles are the water faucet wheel and the door knob.

Enrichment Activities

- Build a cart from spools or bobbins (wheels), straws or pencils (axles), and a tissue box.
- Many craftspeople, such as potters, jewelry makers, and lapidarists, use a wheel and axle. Arrange for students to watch a craftsperson using his or her machine.
- Bring in a five-speed bike. Teach students what the gears do. Then have them take turns riding the bike and discovering when to change gears.

Unit 6: The Pulley

Target Words: *groove, pulley, pulley system*

This unit teaches students that the pulley helps them lift objects with less force; and that pulleys turn moving parts in machines.

PAGE 37: **Belts, Ropes, and Pulleys**

Students learn that a pulley is a wheel with a groove, and a rope or belt loops around the pulley. A pulley system is a rope or belt that goes around two or more pulleys.

In machines, a pulley system usually connects a motor or engine to a moving part. On the diagram, students draw a line from the pulley on the motor to the groove on the roller brush. Other motorized machines with pulley systems are cars and lawn mowers.

PAGES 38–39: **Why Use More than One Pulley?**

Materials: *15 feet of thin rope, strong string, two boards (3 feet and 4 feet long), three curtain pulleys, four thick books (such as desk dictionaries), scissors*

Students make a pulley system with curtain pulleys and rope. Help them conclude that the more pulleys they use, the less force they use. The activity reinforces this principle: *When you move an object over a longer distance, you make work easier.*

What Happens? (Wording may vary.) **1.** I can't lift the books. **2.** It's easy to lift the books.

PAGE 40: **Moving Parts**

Materials: *mayonnaise jar with lid, lid from a mayonnaise jar, 3-inch rubber band, two push pins, hammer, block of soft wood (such as pine)*

Students make a model of a pulley system in a machine. Explain that one pulley is attached to a motor or engine, and the other is attached to a moving part. Help students conclude that when the pulley on the motor spins, the other pulley spins, too, thus turning the moving part.

PAGE 41: **Machine Choice**

Students apply what they learned from all units. Answers may vary. What's most important is students' reasons for their choice(s). Students who have difficulty writing might answer orally. Some students may be unfamiliar with a pick ax. Bring one in.

PAGE 42: **Check Yourself**

(Wording may vary.) **1.** A pulley is a wheel with a groove and a rope or belt that fits into the groove. **2.** A pulley system is two or more pulleys. **3.** You need less force to do work. **4.** They turn moving parts. **5.** The other pulley system is on the crane's long arm.

Enrichment Activities

- Have students construct a rope pulley system from a high place and lift different objects.
- Take a field trip to an auto repair shop. Ask a mechanic to explain how pulley systems work in a car.

Unit 7: Using Machines

Target Words: *forklift, hand truck, ladder*

PAGE 43: **Using Machines**

Students apply what they learned about the five simple machines. From pictures, they write what simple machines make up a lawn mower and backhoe.

Answers may vary. The lawn mower is made up of a wheel and axle, wedge, and lever. The backhoe is made up of a wheel and axle, pulley, lever, inclined plane (screw), and wedge.

PAGE 44–45: **Working in a Warehouse**

Students read about some jobs and choose the machines they would use on those jobs. They also write what simple machines make up those machines.

Answers may vary. You might bring in the machines so students can see them up close. The packing knife and scissors are both made up of a lever and wedge. The stapler is made up of a lever, and the tape dispenser is made up of a wheel and axle and wedge.

The forklift has all five simple machines; the hand truck is made up of a wheel and axle and lever. The ladder can be used as an inclined plane.

Enrichment Activities

- Invite a mechanic or appliance repair person to talk about how an engine or motor works.
- Play "What Machines Do I Use?" Students draw job titles from a box and the others guess what machines are needed for that job.

Show What You Learned

PAGE 46: **What's the Answer?**

1. inclined plane **2.** lever **3.** pulley **4.** wedge **5.** wheel and axle **6.** any of the five simple machines

PAGE 46: **What's the Word?**

1. Force **2.** Work **3.** Concentrate **4.** Simple Machine **5.** Ramp **6.** Increase

TEACHING AIDS

Resources

- Agency for Instructional Television, Box A, Bloomington IN 47401
- Lawrence Hall of Science, University of California, Berkeley, CA 94720
- Hardware stores, auto parts stores, toy stores
- Local carpenters, auto mechanics, painters, repair persons for hand tools and large appliances
- Local artists and craftspeople
- Unions, factories, shipping yards, industrial parks
- Science museums

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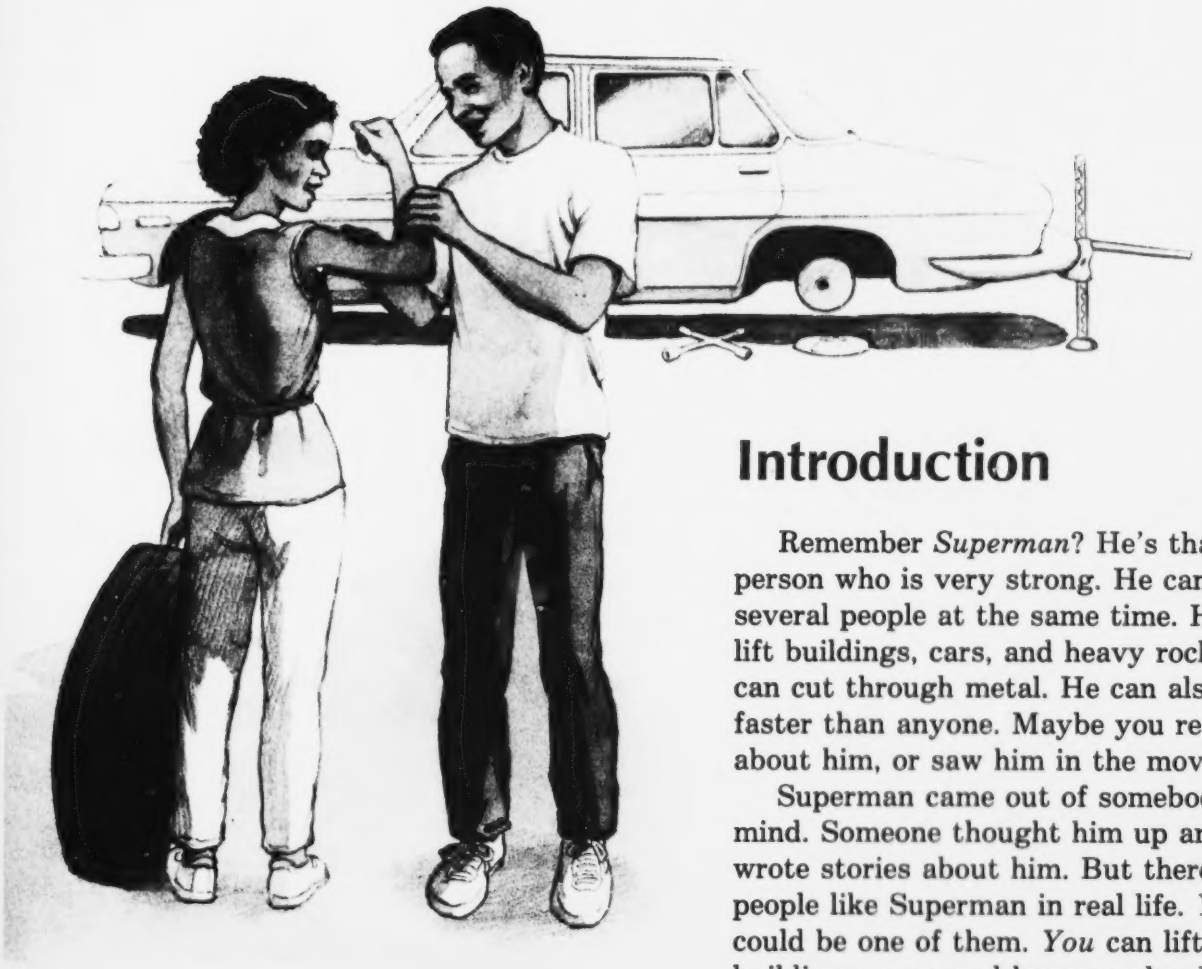


Introduction

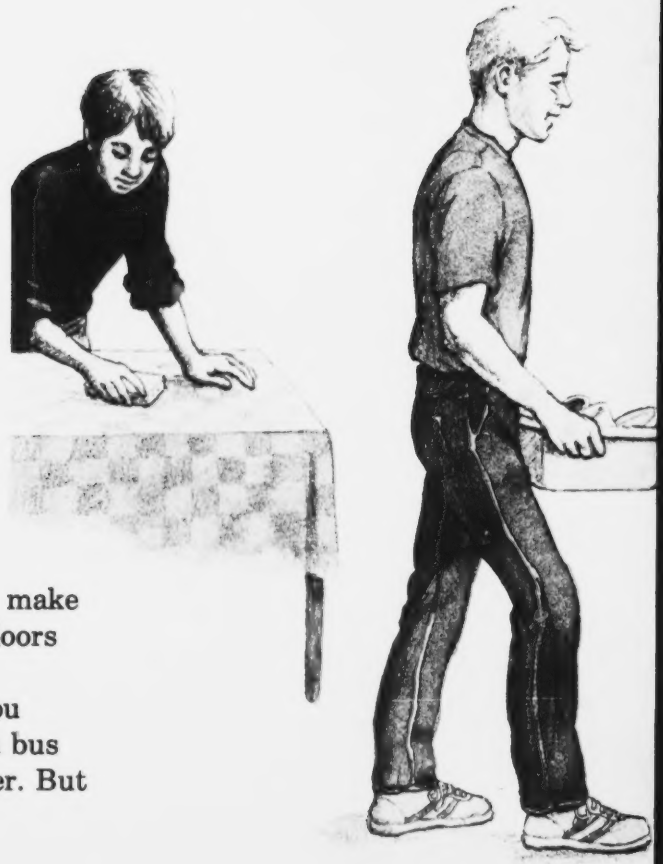
Remember *Superman*? He's that person who is very strong. He can lift several people at the same time. He can lift buildings, cars, and heavy rocks. He can cut through metal. He can also move faster than anyone. Maybe you read about him, or saw him in the movies.

Superman came out of somebody's mind. Someone thought him up and wrote stories about him. But there *are* people like Superman in real life. *You* could be one of them. *You* can lift people, buildings, cars, and heavy rocks. *You* can cut through metal. And *you* can move faster than anyone can run.

How can you do all those things? By using **machines**! That's right. Machines can make you stronger. And they can make you move very fast.

In this book, you'll learn about different machines. You'll learn what they can do for you, and how they make you stronger.

You'll also learn about some machines to use for different kinds of work. Someday you'll have a job. Maybe you already do. This book can show you how to make your work easier!



Unit 1

Making Work Easy

It's Saturday! You're working at home. You make your bed and wash the dishes. You sweep the floors and scrub the tub. Finally your work is done.

"No more work today!" you tell yourself. You walk to a friend's house. You and he will take a bus to an amusement park and ride the roller coaster. But guess what: You're still doing work!

- What is work?
- What things make your work easier?

You'll learn the answers in this unit.

Before You Start

You'll be using the science words below. Find out what they mean. Look them up in the Glossary that's at the back of this book. On the lines below, write what the words mean.

1. **force** _____

_____

2. **tool** _____

_____

3. **work** _____

_____

Doing Work

You probably think you do work when you clean your home. But you also do work when you just *walk*. Why is that so?

_____

_____

You do work because you are moving something from one place to another. What do you move when you walk?

_____

_____

Yes, you move your body.

Work can be easy, such as moving your body across a room. Or work can be hard, such as moving your body up a hill.

Everytime you move something, you either *push* or *pull* it. Slide a pencil across your desk, *away* from you. Do you push or pull the pencil?

_____

Right. You push it away from you.

Now, pick up the pencil. Do you push or pull it up?

_____

Yes, you pull up the pencil.

Whenever you do work, like moving the pencil, you push or pull something. That push or pull is called *force*.

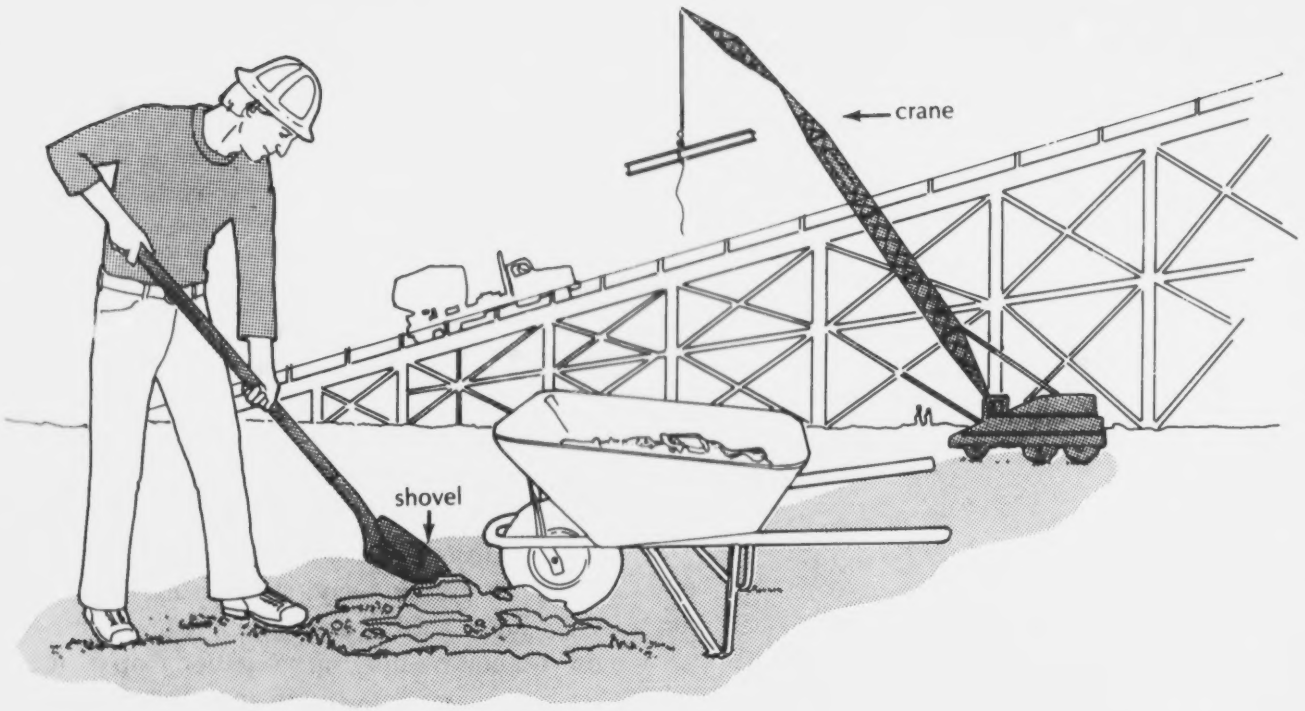
When you do work that's hard, you use a lot of force. You use less force when the work is easy. Think of some work you did that was hard. What work did you do?

_____

What could have made that work easier?

_____

_____



Machines

Lift this book from your desk.

That's easy work. You don't use much force to do that. But suppose you lift a small box of books. Now the work is not so easy. You must use a lot more force.

What if the box of books is *huge*? It's so big and heavy, you can't lift it. No matter how much force you use, you can't move it. How can you move that box?

_____

_____

One way is to use a *machine*. Machines can make you stronger. That's because they help you do hard work with less force. Think of some machines that help you do work. What are they?

_____

_____

_____

You probably thought of machines such as a car or washing machine. But *tools* such as a hammer, saw, can opener, and knife are also machines.

A machine is anything that can help you do work. And every tool helps you do some kind of work.

The picture above shows workers building a freeway ramp. The workers use machines to help them work. One is a large machine called a *crane*. How do you think that machine makes work easier?

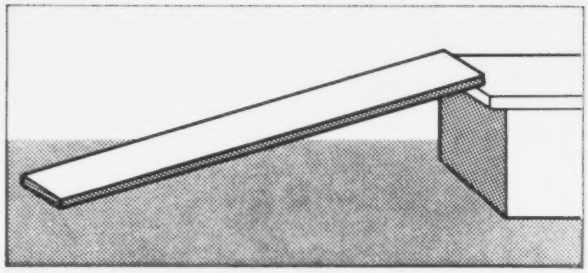
_____

_____

The workers are also using some tools, such as shovels. (Remember: tools are machines.) How does the shovel make work easier?

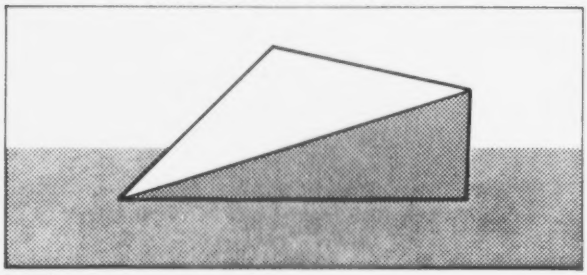
_____

_____



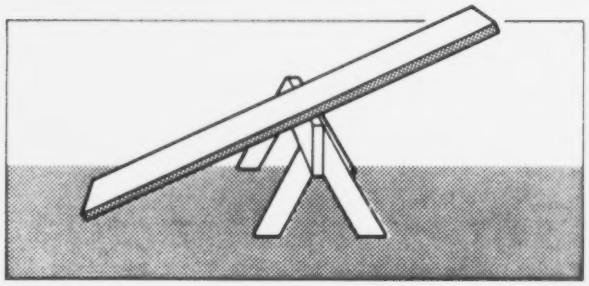
A

Inclined plane



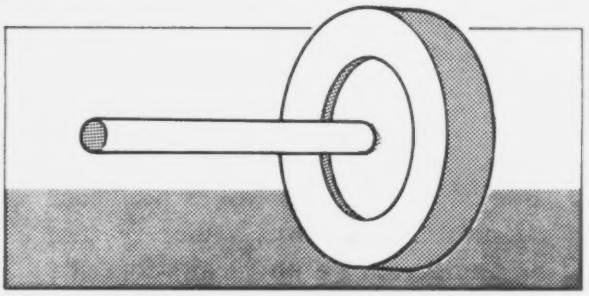
B

Wedge



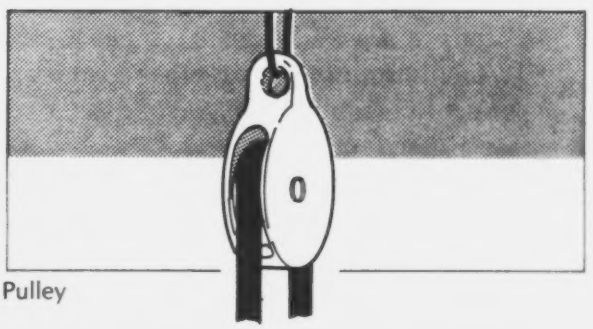
C

Lever



D

Wheel and axle



E

Pulley

Simple Machines

Machines can help you do all sorts of work. Some machines help you lift heavy things. Some machines help you move things. What are some other kinds of work that machines can help you do?

_____

_____

_____

Machines also can help you do these kinds of work: cut food and pound nails, dig holes and open jars.

Machines come in different shapes. Some are small and have a few parts. Others are large and have many parts. But all machines — small and large — are made up of certain parts. Those parts are called **simple machines.**

The pictures on this page show examples of simple machines. Each of those simple machines can be part of a larger machine.

What are the names of the simple machines?

1. Picture **A**:

_____

2. Picture **B**:

_____

3. Picture **C**:

_____

4. Picture **D**:

_____

5. Picture **E**:

_____

Check Yourself

Do the crossword puzzle. The words you'll need are listed on the right. The first one is done.

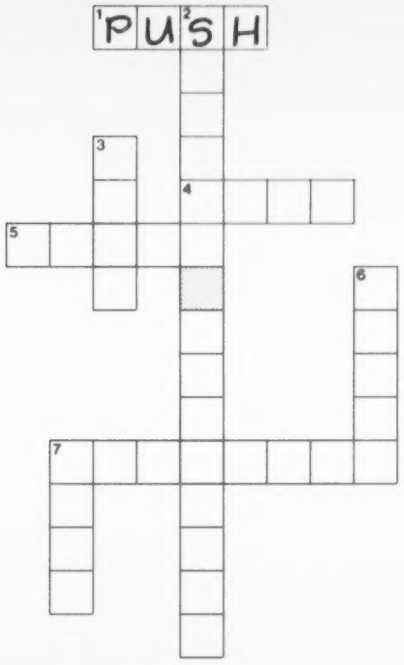
Across

1. You either _____ or pull something when you move it.
4. When you do easy work, you use _____ force.
5. You use _____ when you push or pull something.
7. Things that help you do work.

Down

2. All machines are made of _____ _____.
3. You do _____ whenever you move something.
6. Machines such as a hammer and shovel are also called _____.
7. When you do hard work, you use _____ force.

force	**push**
less	**simple machines**
machines	**tools**
more	**work**

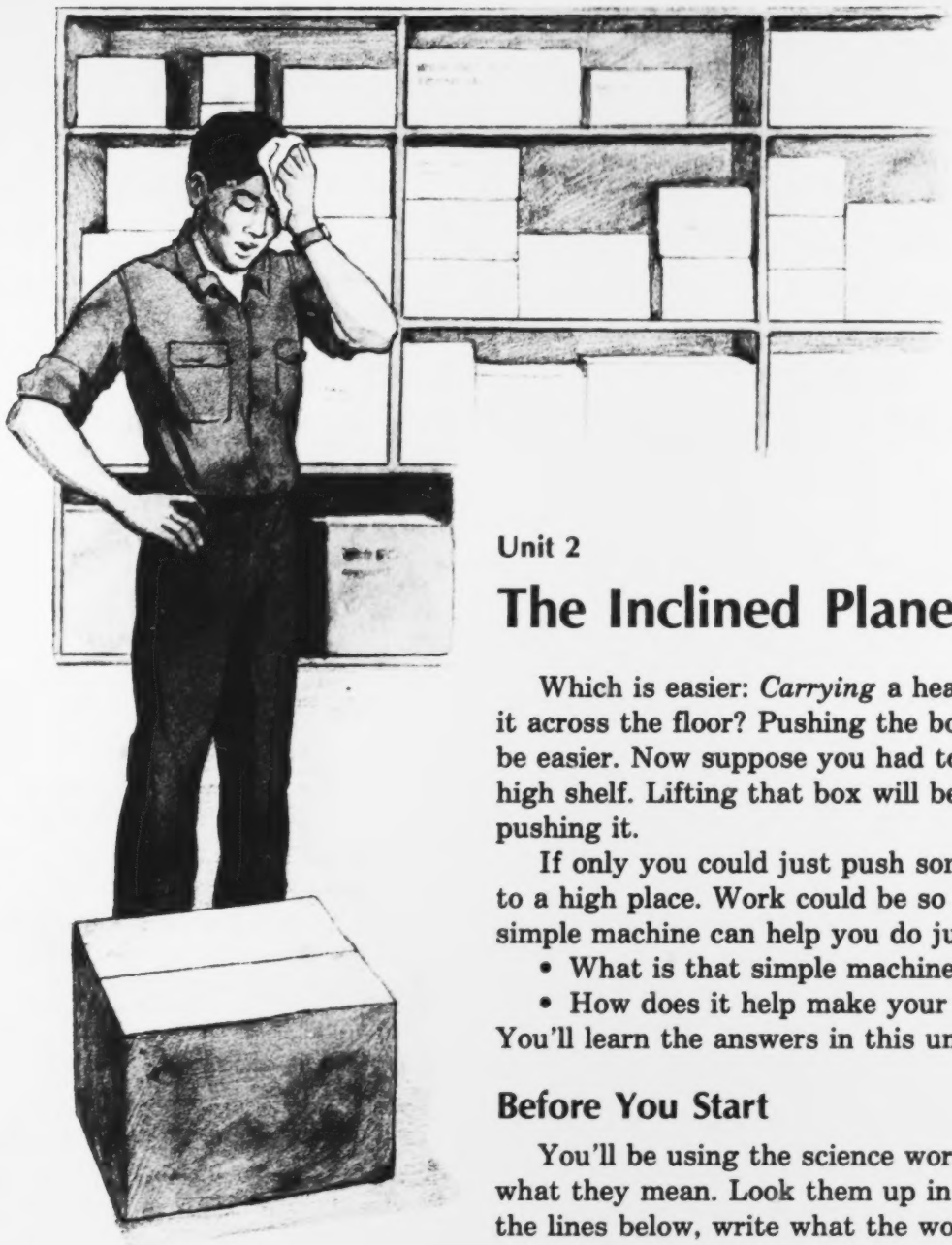


Check These Out

1. Look through magazines and newspapers. Cut out pictures of different machines. Make a poster with them.
2. What jobs do you do around the house? Write down those jobs. Write the names of machines that can help you do your work.
3. What would our world be like if we didn't have machines? Think about it. Then make up a story. Tell or write your story.
4. Choose a machine and find out more about it. Find out who invented the machine and when it was invented. What did it look like then? What does it look like today? How does that machine help people do work? Give a report about that machine.
5. As you work through this book, you may want to find out more about machines. You can find out more by looking in an encyclopedia or by getting books about machines from a library. You can also talk to an expert, such as an auto mechanic, a shop teacher, an engineer, or a physical scientist.

   Here are some things you may want to find out:

   - What is *mass*? What is *weight*?
   - What is *gravity*? How does gravity affect how much force you use to move an object?
   - What was the Industrial Revolution? How did it change our history?



Unit 2

The Inclined Plane

Which is easier: *Carrying* a heavy box or *pushing* it across the floor? Pushing the box probably would be easier. Now suppose you had to place the box on a high shelf. Lifting that box will be even harder than pushing it.

If only you could just push something from a floor to a high place. Work could be so much easier. One simple machine can help you do just that.

- What is that simple machine?
- How does it help make your work easier?

You'll learn the answers in this unit.

Before You Start

You'll be using the science words below. Find out what they mean. Look them up in the Glossary. On the lines below, write what the words mean.

1. **ramp** _____

_____

2. **slope** _____

_____

3. **steep** _____

_____

Ramps

Picture this:

You're a member of a band. And you're loading equipment into a van. The loudspeakers are too heavy to lift. Is there a way to push the loudspeakers into the van?

Yes! You can use a *ramp*. The ramp is an **inclined plane** — a simple machine.

To make the ramp you get a long board. You lean one end of it against the van. The board is now a ramp! You put the loudspeakers on the ramp, and push them up and into the van.

Remember: a machine can help you do work. How do you think inclined planes make work easy? (Hint: Look at the picture.)

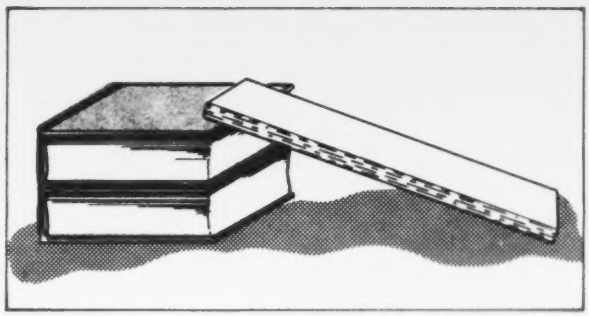
An inclined plane connects a low place to a high place. So it lets you slowly push or pull something up to the high place. You use less force moving it that way than if you carry it.

Ramps or inclined planes are easy to make. All you need is a board. Think of a time when you had to lift a heavy thing. Could a ramp have helped you then? What thing were you trying to lift?

Concrete or wood ramps are often built into streets and buildings. For example, ramps for handicapped people are built. How do you think those ramps make work easy?

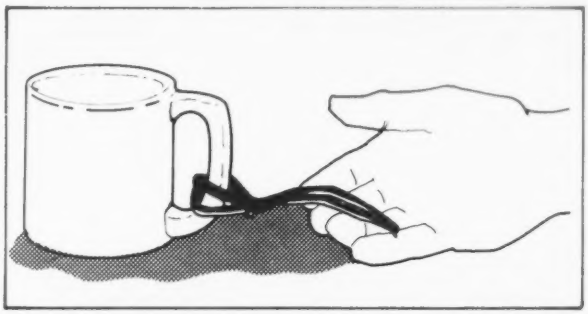
How Much Force?

A machine makes your work easier. Find out how an inclined plane makes work easy. You'll need these things: a 1-foot long board, two thick books, a heavy coffee cup, and a thin rubber band.



1

First make a ramp. (Remember: a ramp is an inclined plane.) Stack the books. Then lean one end of the board on the books.



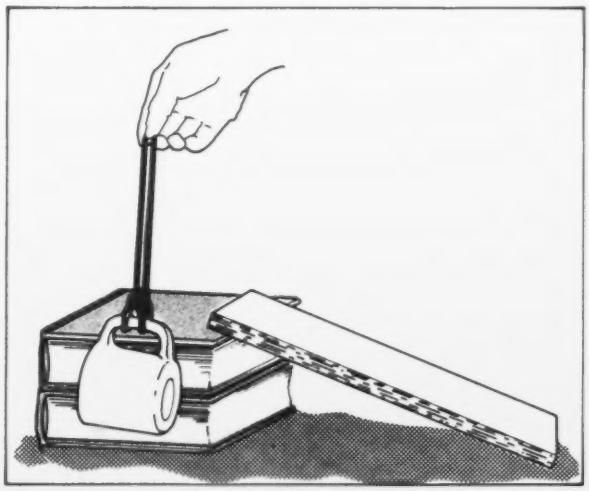
2

Loop the rubber band around the cup handle, the way the picture shows. The rubber band will show how much force you use to move the cup. The more the rubber band stretches, the more force you use.

3

Put the cup next to the books. Hold the rubber band and lift the cup. Lift it to the top of the ramp.

Look at the rubber band. Does it stretch a lot or little?



_____

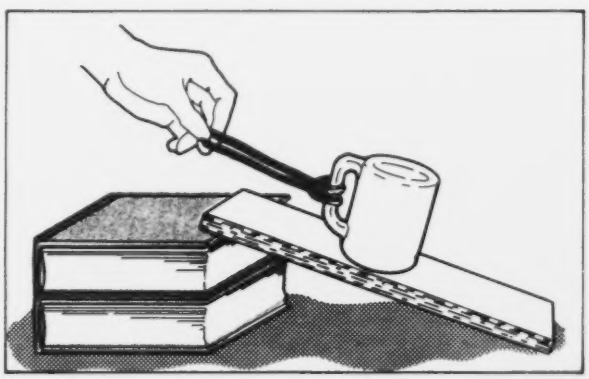
4

Now put the cup at the bottom of the ramp. Pull the rubber band and slide the cup up the ramp. Does the rubber band stretch more or less than before?

_____

The rubber band should stretch less.

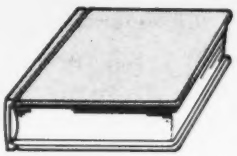
When do you use less force: When you pick up the cup or when you slide it up the ramp?



_____

Experiment 1
What kind of inclined plane makes work easier?

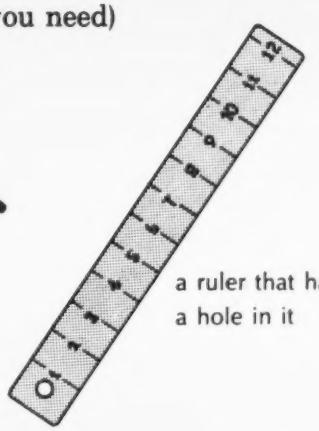
Some inclined planes are steep. Some are not. Which kind makes work easier? Do this experiment and find out.



twelve thick books (all the same size and thickness)

Materials (What you need)

a coffee cup with a rubber band tied to its handle



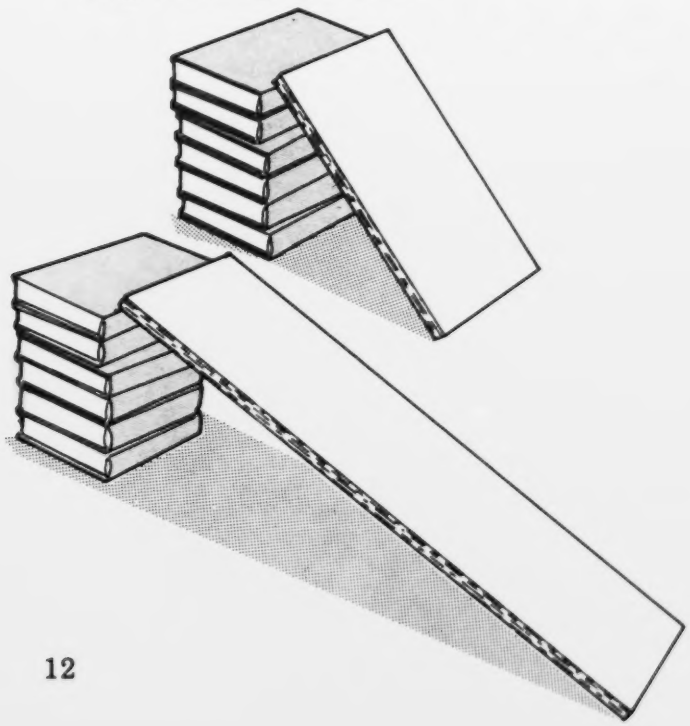
a ruler that has a hole in it

a 1-foot long board

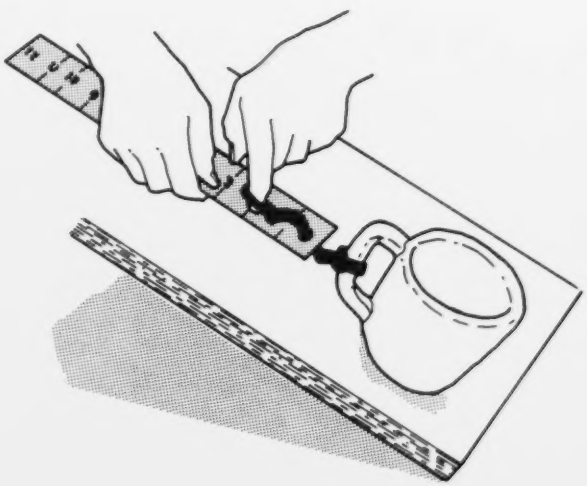
a 3-foot long board

Procedure (What you do)

1. Make two ramps: Stack six books, and lean the short board against them. Stack the other books, and lean the long board against them.

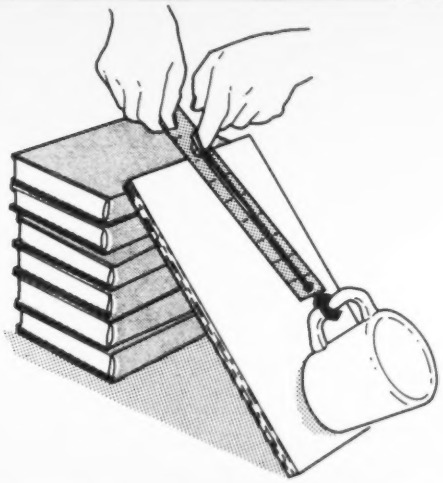


2. Put the cup on the bottom of the short ramp. Put the end of the rubber band through the hole in the ruler.



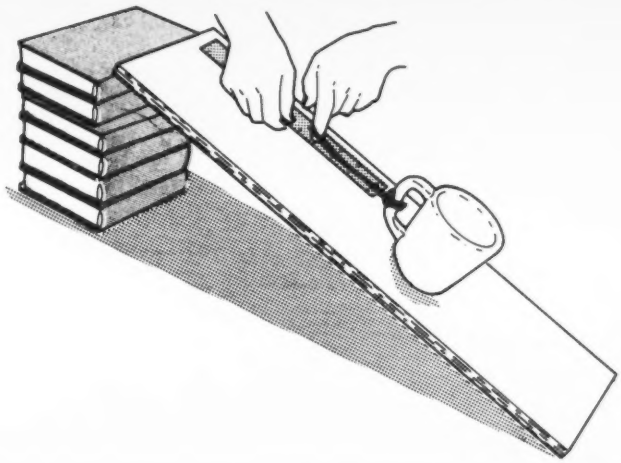
3. Pull the rubber band and slide the cup up. Look at the ruler as you pull. How much does the rubber band stretch?

_____ inches



4. Put the cup on the long ramp. Pull it up as before. How much does the rubber band stretch?

_____ inches



Observations (What you see)

1. Which makes a steeper slope: the short board or the long board?

_____

2. Where does the rubber band stretch less: on the short ramp or on the long ramp?

_____

Conclusions (What you learn)

1. When do you use more force?

_____ moving things up a slope that's very steep

_____ moving things up a slope that's not so steep

2. When is work easier?

_____ moving things up a very steep slope

_____ moving things up a less steep slope

3. Suppose you're making a ramp. Which makes your work easier: a short ramp or a long ramp?

_____

Machine Choice

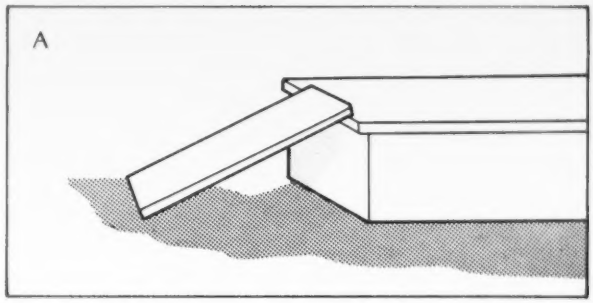
You learned that inclined planes can help make your work easier. Read these two problems. Decide which inclined plane is the best choice.

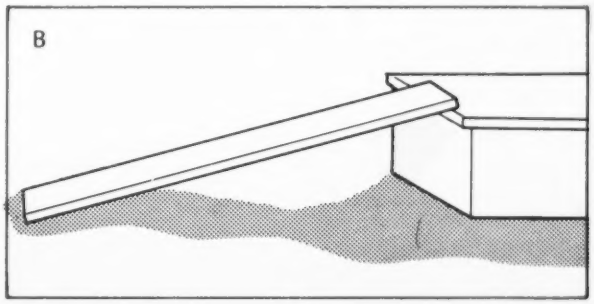
1

Picture this:

You're a delivery person for a large store. You're delivering a freezer to someone's home. But there's a high step from the ground to the front door.

You decide to make a ramp. Picture **A** and picture **B** show two ramps you can make. Which ramp do you make: the one in picture **A** or **B**?





Why do you make that ramp?

2

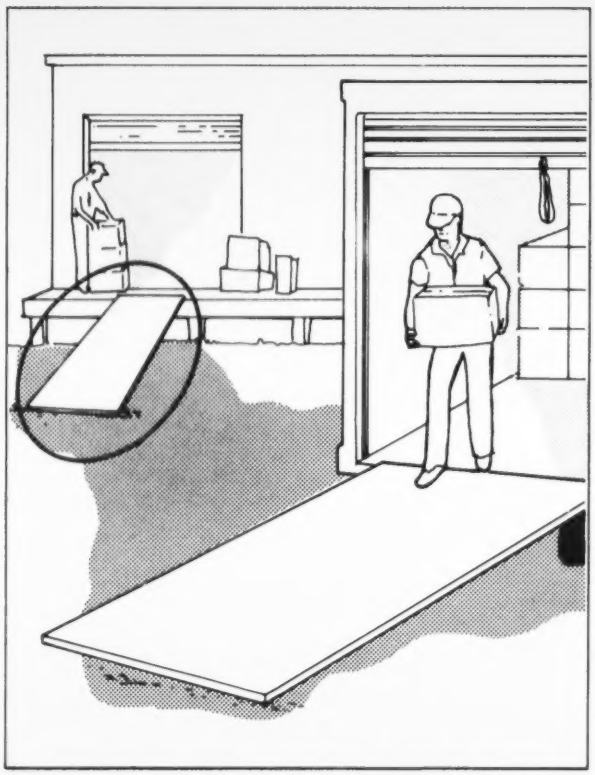
Suppose you have a broken foot. You're on crutches. You're going to a health center that's at the top of a hill. What's the best way for you to get up the hill: Should you walk up the stairs? Or walk up the cement path?

Why do you say that?

Check Yourself

Finish these sentences. Put an X in front of the right word or words.

1. An inclined plane can make your work
   _____ a. easier.
   _____ b. harder.
   _____ c. difficult.
2. An inclined plane connects
   _____ a. a low place to a high place.
   _____ b. two places that are the same height.
   _____ c. two things that are moving.
3. An inclined plane helps you
   _____ a. cut things.
   _____ b. split things.
   _____ c. lift things.
4. When an inclined plane is steep you use
   _____ a. less force.
   _____ b. more force.
   _____ c. no force.



5. Look at the picture. It shows two inclined planes. One is circled. Find the other one and circle it.

Check These Out

1. Find pictures of different inclined planes. Look through magazines and newspapers. Cut out the pictures. Then make a poster with those pictures.
2. How do you think the first inclined plane was invented? Write a story about what you think happened.
3. Many roads go up steep hills and mountains. Invite someone who builds roads to your class. Ask that person to talk about the problems they have building those roads.
4. The pyramids of Egypt were built over 4,500 years ago. Find out how people used inclined planes to make them. Draw a picture of a pyramid. Tell how it was built.
5. Here are more things to find out:
   - Why is the screw an inclined plane? What are some examples?
   - What amusement rides have inclined planes?
   - Why is an *escalator* an inclined plane? How does it work?

Unit 3

The Wedge

You cut food with a knife. You open cans with a can opener. The knife and can opener both are machines. They help you do some kind of work. You learned that machines can be made up of simple machines. Both the knife and the can opener have parts that are **wedges**. The wedge is a simple machine.

- What is a wedge?
- How does it make your work easier?
- What different jobs can you use a wedge for?

You'll learn the answers in this unit.

Before You Start

You'll be using the science words below. Find out what they mean. Look them up in the Glossary. On the lines below, write what those words mean.

1. **concentrate** _____

_____

2. **split** _____

_____

Pushing Things Apart

Suppose you're chopping wood for a fire. You chop long pieces of wood into short, thin pieces. What tool do you use?

_____

You use an *ax*. The ax has a part that can split things. That part is another simple machine — the *wedge*.

Look at the picture of a wedge. Now get a dark pencil. Draw a line around the shape of the wedge. How would you describe that shape?

_____

The wedge is a triangle. One end is wide. The opposite end is pointed. Because the wedge has that shape, it can move through things. It can push them apart.

For instance, you use a knife to cut an apple in half. The sharp part of the knife is a wedge. It cuts into the apple. Then it pushes the two sides of the apple apart.

Axes and scissors also have wedges. What other tools have wedges?

_____

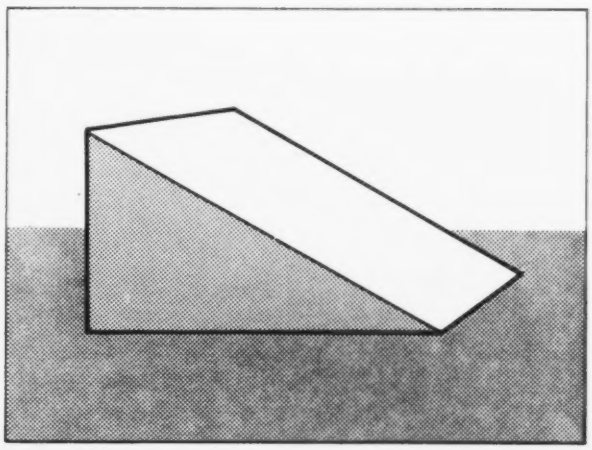
_____

_____

Some wedges can help you lift things and hold them in place. A doorstop is a kind of wedge. When you put it between a door and the floor, this happens: It pushes the door up a little. And it holds the door in one place.

Where else could you put a wedge to lift something and hold it in place?

_____



A wedge

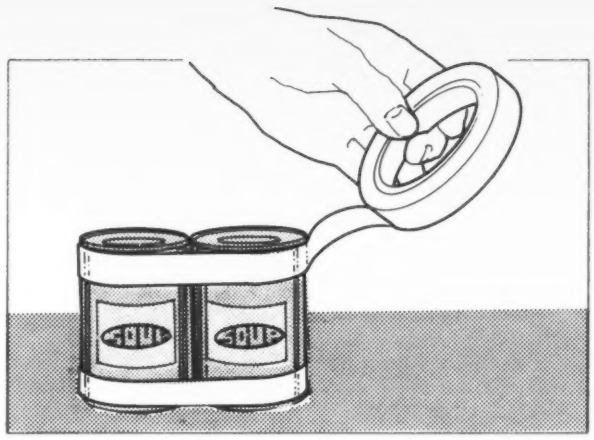
Wedges Make You Stronger

It is very hard to split things apart. A wedge can help you do that. That's because a wedge *concentrates* the force you use. It puts that force in a very small place. It makes you stronger than you are.

See how a wedge concentrates your force. You'll need a wedge, such as a doorstop. You'll also need two soup cans, one book, and masking tape.

1

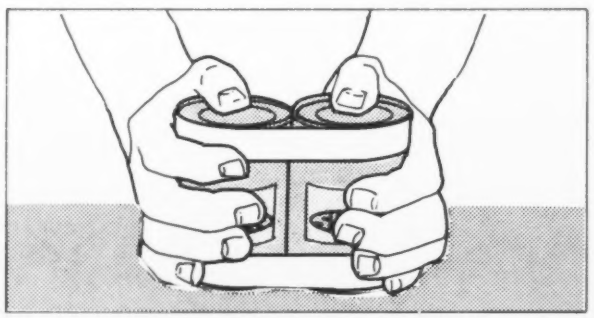
Tape the two cans together. Tape them all around the top and bottom.



2

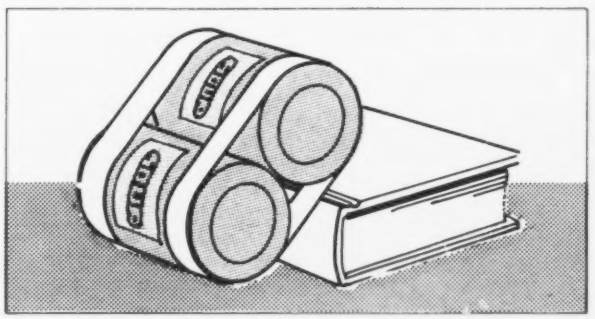
Hold one can in each hand. Pull on the cans. What happens?

Did you say "Nothing"? No matter how hard you pull on the cans, you won't split them apart.



3

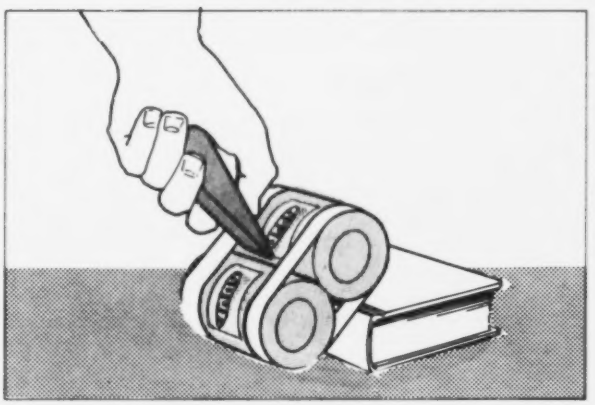
Now, lean the cans on the book the way the picture shows.



4

Put the pointed end of the wedge between the two cans. Push the wedge completely between the cans. What happens?

Right. The wedge concentrates your force — and you split the cans apart!



Different Shapes

Wedges have different shapes. So we use wedges to do different kinds of work. One kind of wedge makes holes. And another kind cuts things. What does a third kind of wedge do?

_____

That's right. It splits things apart.

Many different machines have wedges. Very large machines called *backhoes* have wedges. (Backhoes are used on jobs such as building freeways.) Look at the picture on the cover. It shows a backhoe. How do you think its wedges help workers?

_____

The wedges help workers dig into the earth and split heavy rocks.

Smaller machines such as a lawn mower have wedges. What do the wedges on a lawn mower do?

_____

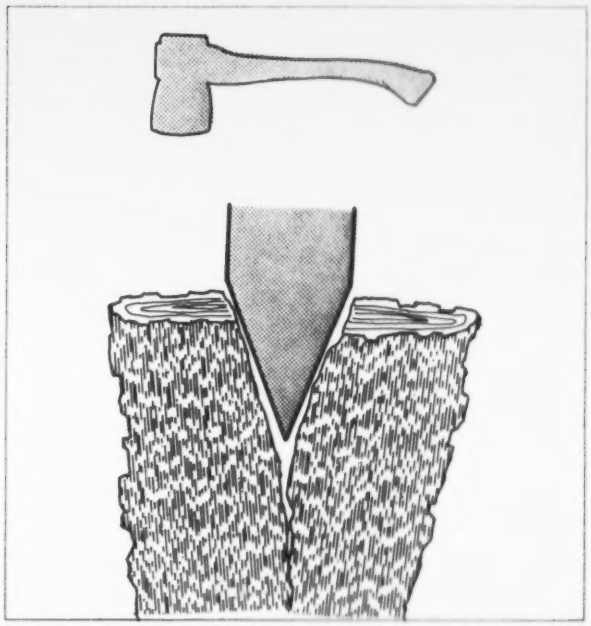
Wedges are also part of small things such as pins and needles. They don't cut or split things apart. What do they do?

_____

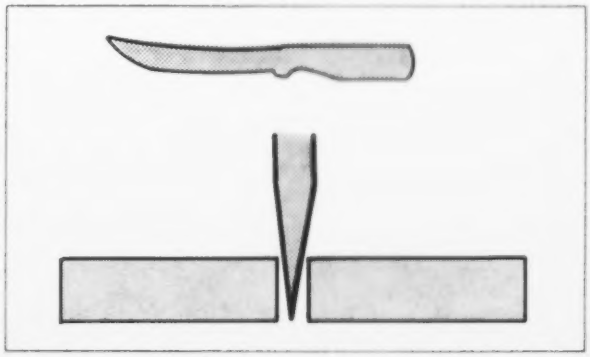
Right. They make holes in things.

Here are some other machines that have wedges. What kinds of work do they help you do? Write *cuts*, *splits apart*, or *makes holes*.

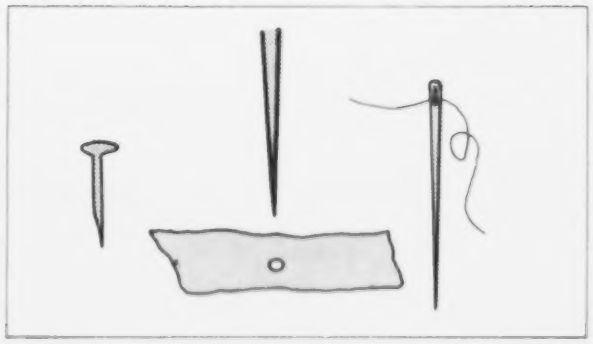
1. scissors: _____
2. knife: _____
3. nail: _____
4. chisel: _____
5. ax: _____



Splits apart



Cuts



Makes holes

Machine Choice

The picture shows some tools that have wedges. Different workers use them. Suppose you are a worker. What tool would you use? Write the name of the tool. Then check your answers. (The right answers are upside down.)

1. You're a cook's helper in a restaurant. You cut many vegetables. Which tool do you use?

   _____

2. You work at a gas station. You are cutting a hole in a can of motor oil. What tool do you use?

   _____

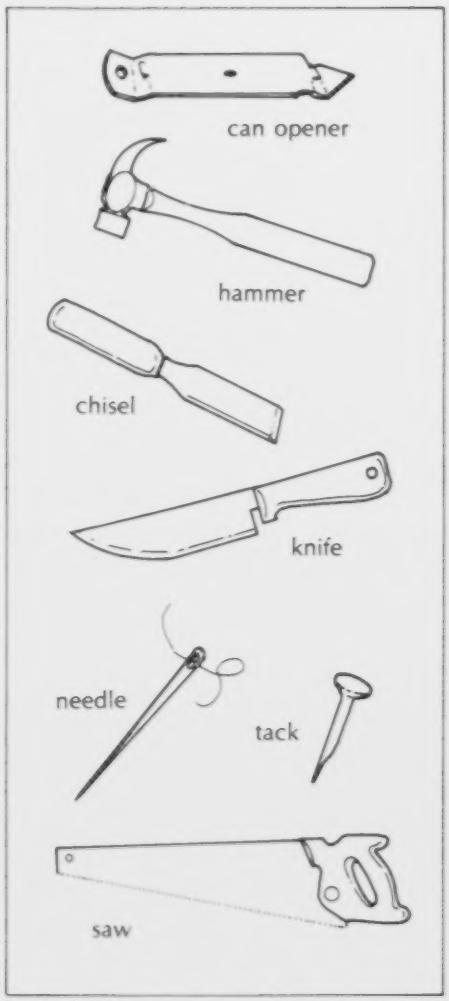
3. You work in a grocery store. You open a wooden box that's nailed tightly shut. You use two tools to open it. Which tools do you use?

   _____

   _____

4. You work in a clothing store. You are sewing the hem of a skirt. Which tool do you use?

   _____



Answers

1. knife 2. can opener 3. hammer and chisel 4. needle

Check Yourself

Finish these sentences. Put an **X** in front of the right answers. There may be more than one answer for a sentence.

1. A wedge is a simple machine that

   _____ a. is round.

   _____ b. is like a triangle.

   _____ c. is like a square.

2. Wedges can be used to

   _____ a. cut things.

   _____ b. split things.

   _____ c. make holes.

3. When you use a wedge, you

   _____ a. use less force.

   _____ b. concentrate your force.

   _____ c. use no force.

4. Wedges are part of

   _____ a. large and small machines.

   _____ b. tools.

   _____ c. steps.

5. Look at the picture. It shows two wedges. One wedge is circled. Find the other and circle it.

Check These Out

1. Many sharp wedges, such as those on knives and scissors, can hurt you. What are some safety rules for using sharp wedges? Write them down on paper.
2. Find pictures of different wedges. Look through magazines and newspapers. Cut the pictures out and paste them on poster paper.
3. Why is a rowboat shaped like a wedge? Find a picture of a rowboat and bring it to class. Start a discussion with your classmates about the boat's shape.
4. Some wedges such as needles are used to make holes. Find out what other wedges do that. Make a list of those wedges.
5. Here are more things to find out:
   - What did the first tools that people made look like?
   - What are some large machines that have wedges?
   - Who was Cyrus McCormick? What big machine did he invent? How are wedges important parts of that machine?

Unit 4

The Lever

Did you ever take a tire off a car?

If you did, you probably used three different tools. You used one tool to take the hubcap off. Another tool to unscrew the nuts that hold on the wheel to the car. And one more tool to help you lift the car.

Those three tools are all examples of one kind of simple machine: the **lever**. Levers let you do very hard work that you are not strong enough to do.

- What is a lever like?
- How does a lever work?
- When do we use levers?

You'll learn the answers in this unit.

Before You Start

You'll be using the science words below. Find out what they mean. Look them up in the Glossary. On the lines below, write what the words mean.

1. **fulcrum** _____

_____

2. **increase** _____

_____

3. **object** _____

_____

Getting Stronger

How strong are you? Can you take off a wheel nut with just your fingers? Carry 300 pounds of rocks in your arms? Open a can of paint with just your fingernails?

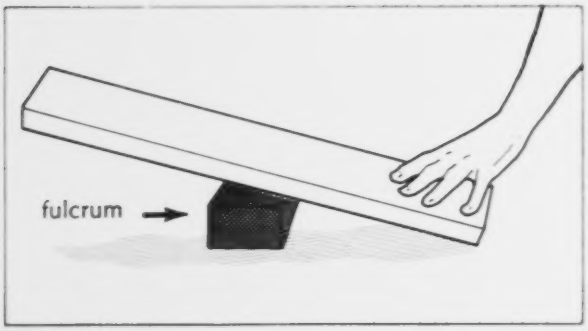
Most of us can do just so much hard work. That's because our muscles can push or pull with only so much force. And it isn't enough to move something that's tightly stuck together, such as a nut and bolt, or the lid on a can of paint.

To do those kinds of hard work we use a lever. Levers can make us stronger than we are.

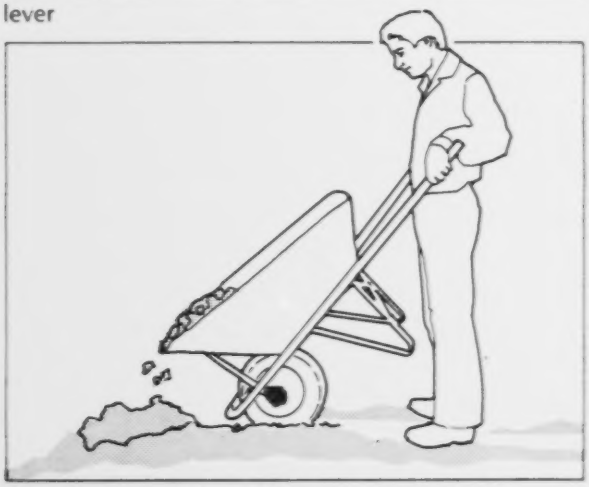
There are many different kinds of levers. Some of them look very different from each other. But all levers use a *fulcrum*. A lever cannot work without a fulcrum. Look at the lever in the top picture. What part is the fulcrum? Draw a circle around it.

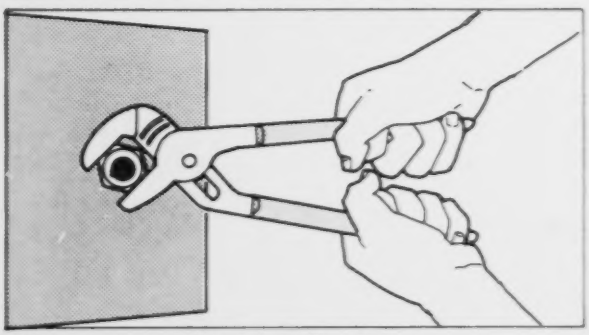
Levers work this way: You rest the lever against a fulcrum. You push one end of the lever against the fulcrum. That makes the other end of the lever push whatever is on it or next to it. That end moves that thing with greater force than the force you use to push the lever.

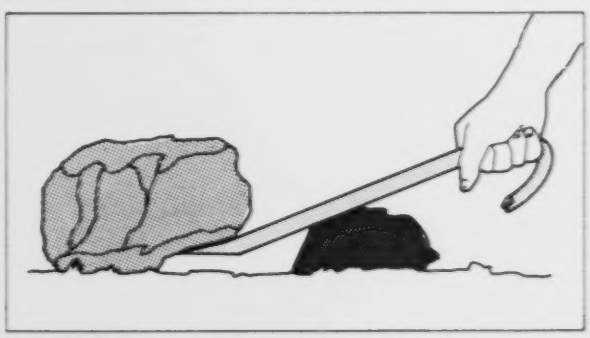
Look at the pictures of tools. They all are machines that are also levers. See if you can find their fulcrums — the parts that you push the levers against. Draw a circle around each fulcrum. Then check yourself. The answer is upside down.



lever


The wheelbarrow is used to carry heavy loads.


Pliers can be used to take off nuts.


A crowbar can move something that is stuck.

Answer

All the dark parts in the pictures are fulcrums.

Experiment 2

Which makes you stronger: a short or a long lever?

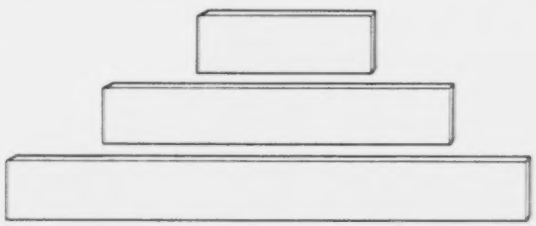
Think about this: You can lift a person with only your thumbs! All you need is a board and a book. What do you do with those things?

Right! You make a lever.

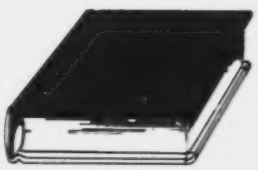
When you use a lever, you can sometimes lift objects with very little force. That's because a lever *increases* your force.

Can a short lever increase force more than a long lever? Get a partner and find out.

Materials



three boards: 2 feet, 4 feet, and 6 feet long



a thick book, such as a desk dictionary

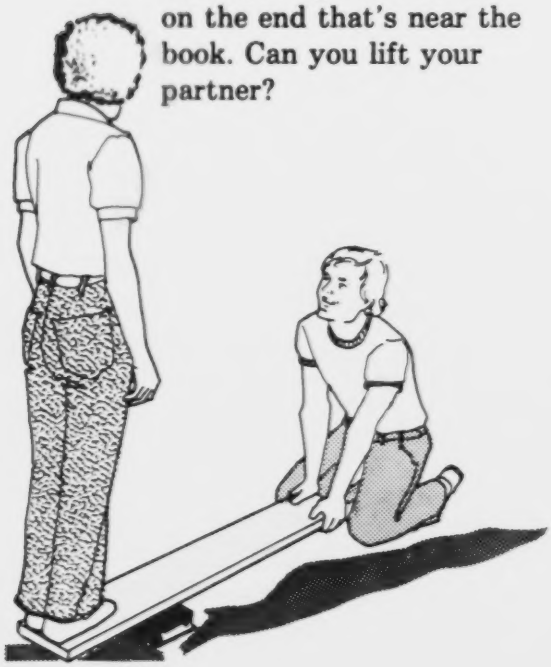
Procedure

1. Lay the shortest (2 feet) board on the book. The book should be under the center of the board.

2. Your partner stands on one end. With your hands, push down on the other end. Can you lift your partner?

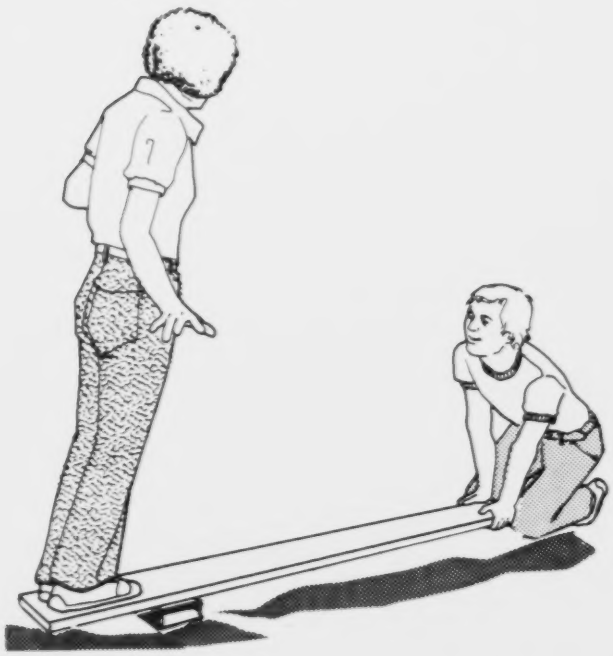
3. Lay the next-sized (4 feet) board on the book. (The end should be 1 foot from the book.)

   Have your partner stand on the end that's near the book. Can you lift your partner?



1 foot

4. Now do the same with the longest (6 feet) board. (The end should be 1 foot from the book.) Can you lift your partner?



1 foot

Observations

1. Which lever first lifts your partner?

   _____

2. Which lever is the easiest to use? (Hint: Think of the one you push with the *least* force.)

   _____

3. Which lever do you push with the most force?

   _____

Conclusions

1. Which lever lets you use less force: a short or long one?

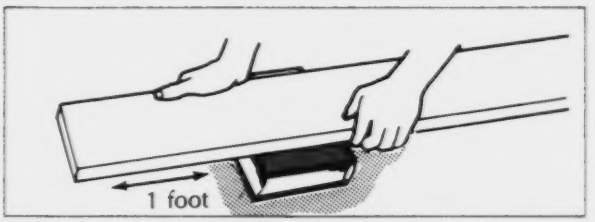
   _____

2. Which lever increases your force: a short or long one?

   _____

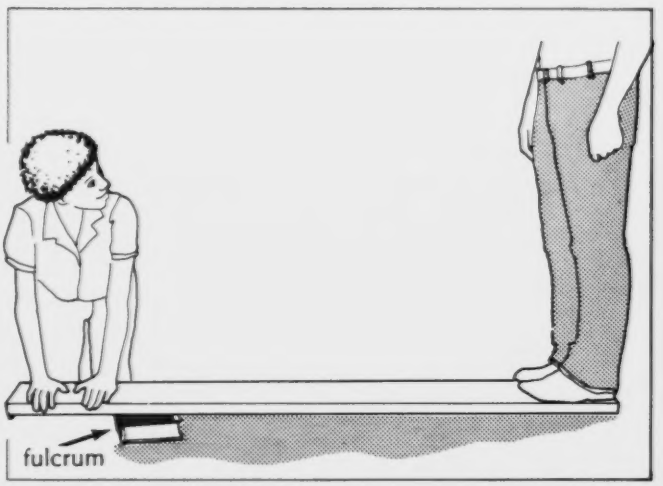
Where Do You Put the Fulcrum?

All levers have a fulcrum. You can put that fulcrum anywhere on the lever. Find out what happens when you change the place you put the fulcrum. You'll need a thick book and a board 6 feet long. You'll also need a partner.



1

Lay the board on the book. The book should be 1 foot from the end of the board. The book is the fulcrum.



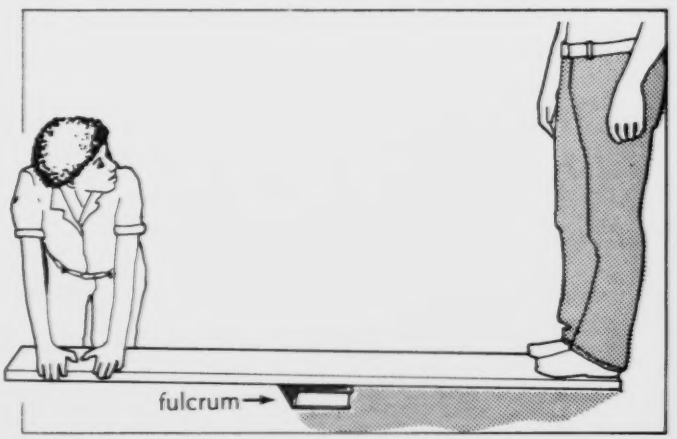
2

Your partner stands on the end that's *farthest* from the fulcrum. With your hands, push down on the other end. What happens?

_____

3

Now place the book beneath the center of the board. Your partner stands on the same end again. Push down on your end. What happens?



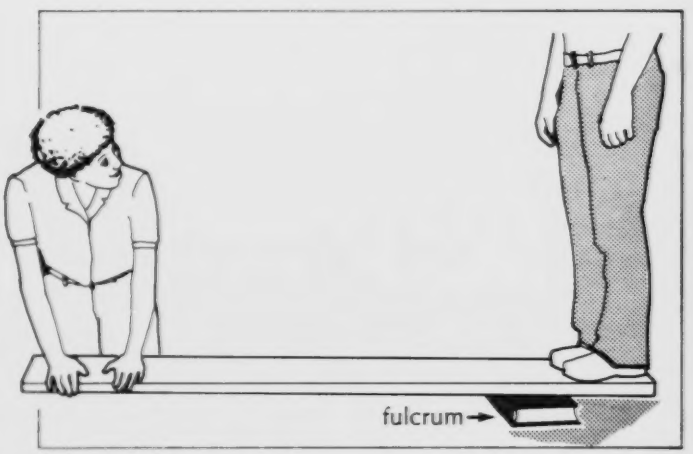
_____

4

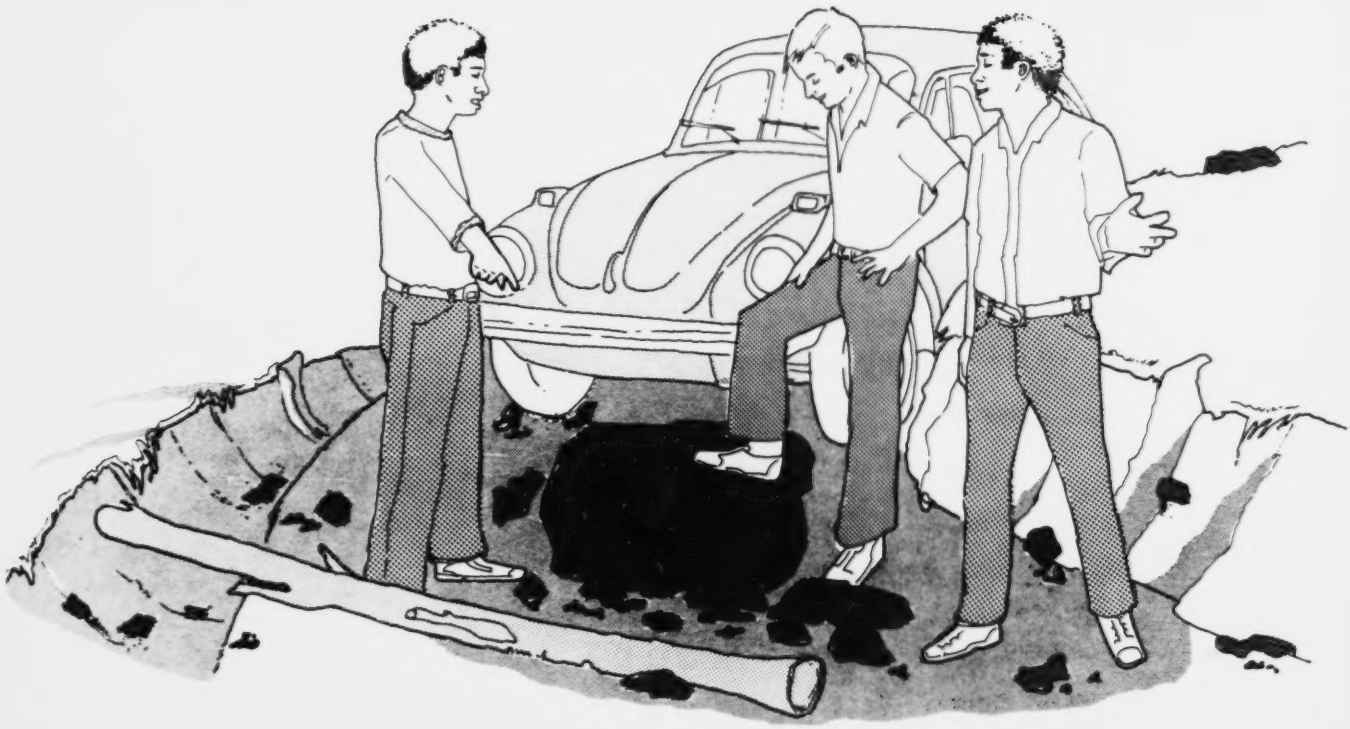
Place the book so it's 1 foot from the end that your partner stands on. Push down on your end. What happens?

_____

Where should you put a fulcrum when you have an object that's hard to move: near or far from that object?



_____



Machine Choice

Picture this:

You and your friends have been camping. And now you're driving home.

Suddenly you stop. A huge rock has fallen in the middle of the road! And you can't get around it. How can you move that rock out of the way?

You have a car jack and a crowbar in the car trunk. And on the ground you see a long, heavy branch that fell off a tree.

You can use the car jack, the crowbar, or the branch as a lever. Which one do you pick?

_____

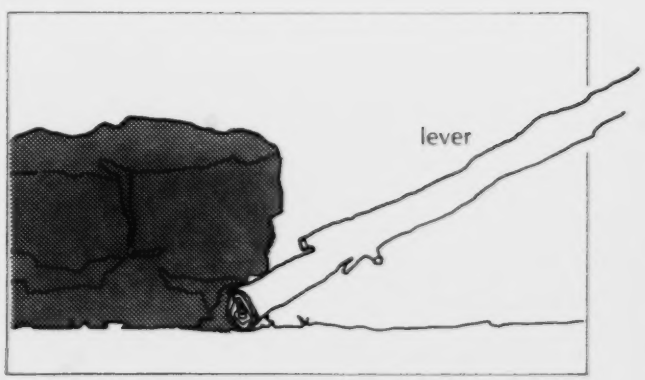
Why?

_____

_____

_____

You find a smaller rock to use as your fulcrum. Where would you put it? On the picture at the right, draw the fulcrum.



Check Yourself

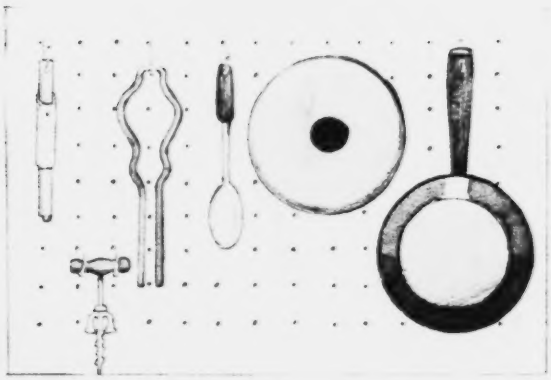
Finish each sentence. Put an X in front of the right words. There may be more than one correct answer.

1. Levers help you
   - _____ a. lift heavy objects.
   - _____ b. move objects that are stuck.
   - _____ c. split objects.
2. A fulcrum is
   - _____ a. another name for a lever.
   - _____ b. the place that a lever turns about.
   - _____ c. the object you move.
3. When a fulcrum is close to an object, you
   - _____ a. use less force to lift it.
   - _____ b. use more force to lift it.
   - _____ c. can't lift it.

4. Look at the picture. It shows three levers. One lever is circled. Find the other levers and circle each one.

Check These Out

1. One kind of can opener is a wedge and a lever. That kind of lever is sometimes called a *church key*. Bring one to class. Explain why it is a wedge and a lever. Find the fulcrum. Explain how the can opener works.
2. Many large machines, such as cranes, have levers. Find pictures of different large machines. Look in magazines and newspapers. Post the pictures on a bulletin board. Ask others to find the levers.
3. What levers do you have at home? Make a list.
4. Bring examples of levers to class. Give a report about each one.
5. Here are some other things you may want to find out:
   - What does *mechanical advantage* mean?
   - How is your arm like a lever?
   - What are *compound levers*? What are some examples?



Unit 5

The Wheel and Axle

Riding a bus is easier work than walking.

Using an eggbeater to mix batter is easier than beating it with a fork.

The bus and the eggbeater both make work easier. They are machines that have many parts. One of those parts is the simple machine you'll be learning about. That machine is the **wheel and axle**.

- What are the wheel and axle like?
- How do they make work easier?
- How do they make parts in machines move?

You'll learn the answers in this unit.

Before You Start

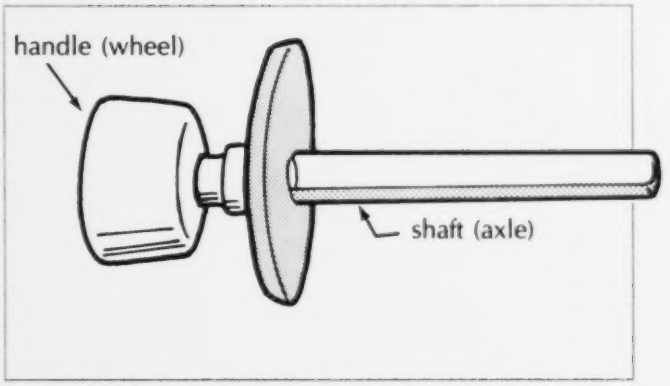
You'll be using the science words below. Find out what they mean. Look them up in the Glossary. On the lines below, write what they mean.

1. **control** _____

_____

2. **gear** _____

_____



a doorknob

Moving in Circles

Look at the picture of the tightly closed door. Could you open a door like that by just pushing it?

You woudn't be able to open that door, no matter how hard you pushed it. That's because a metal part inside the door—the *latch*—sticks out of the door and into the door frame. To open the door, you must move the latch. You do that by using a simple machine called the *wheel and axle.* What door part do you think is a wheel and axle?

Right! The *doorknob* is a wheel and axle.

The wheel and axle is made up of two kinds of parts. One part turns in a circle like a wheel so it is called the *wheel.* The other part is attached to the wheel, and moves in a smaller circle in the center of it. That part is called the *axle.*

When you turn the wheel, you cause the axle to also turn. What do you think happens when you turn the axle?

Right! The wheel also turns.

Look at the picture of the doorknob. It shows the two kinds of parts that make up that simple machine. The handle of the doorknob is the wheel. The shaft is the axle. The shaft is placed next to the latch. When you turn the handle, you turn the shaft—and that moves the latch so you can open the door.

Some other examples of wheels and axles that work like the doorknob are radio knobs, water faucet handles, windmills, and the controls on appliances such as gas stoves. Each has a part that turns like a wheel and a part connected to it that is an axle. When the wheel or the axle turns, it causes the other part to also turn.

Sometimes you'll see wheels and axles on things such as roller skates and shopping carts. Those wheels are not connected to the axle. The wheels turn around the axle, but the axle does *not* turn. Do you think those wheels and axles are simple machines? Why?

Increase Your Force

In Unit 4, you learned that the lever increases your force. It helps you move objects that are difficult to move. A wheel and axle also increases your force so that you can move things.

In fact, a wheel and axle is like a lever that moves in a circle. You push against a part that moves in a large circle. That causes a second part to also move in a small circle inside the large circle. That second part moves the object that is connected to it.

A wheel and axle helps you do things you couldn't do with just your own force. It helps you haul and hoist heavy objects, move objects that are tightly stuck, and push objects.

You've probably used a wheel and axle and not realized that you have. That's because many wheels and axles do not look like a wheel. A wheel and axle does not need to *look* like one. it just needs to move like a wheel.

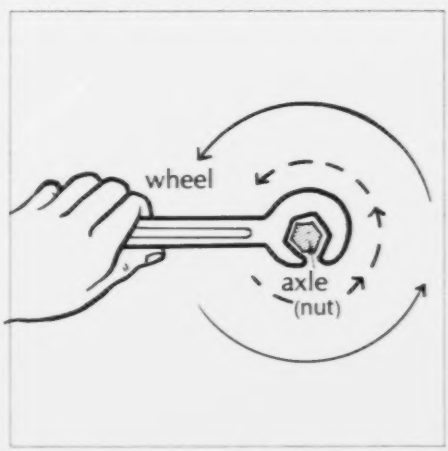
For instance, a wrench is a wheel and axle. You use it to tighten or take off nuts and bolts.

Look at the picture of a wrench. Notice that it is made up of a handle and a part that fits snugly on a bolt or nut.

Let's say you're taking a nut off a bicycle wheel. In order to do that, you fit the wrench on the nut, then you turn the handle in a circle until the nut comes off.

Which part of the wrench moves in a large circle?

Some wheels and axles.



You can use a wrench to take off a nut.

Right. The handle moves in a large circle. That part is the wheel. The part that fits on the nut moves in a small circle. That part is the axle.

You can see how a wheel and axle lets you do work you couldn't do by yourself. Get a jar that's so tightly shut you can't open it with your hands alone. Get a jar opener and use it to open the cover.

How does the jar opener work like a wheel and axle?

Another Kind of Wheel and Axle

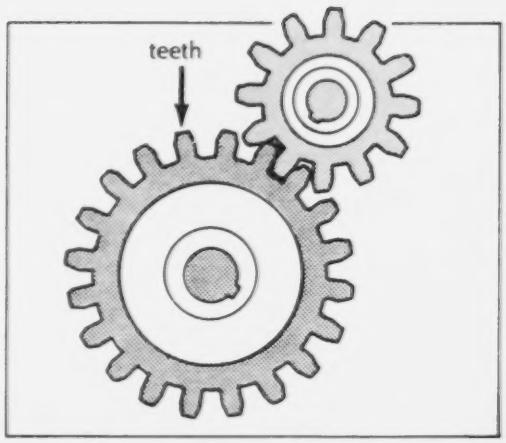
You've probably seen watches with hour and minute hands. Have you ever looked inside one? If you did, you'd see several tiny **gears**. Those gears are a kind of wheel and axle.

Many machines — large and small — have gears. They move parts in a machine. For instance, gears move the hands in a watch.

Here's how gears work: A gear turns another gear. That gear is joined to a part in a machine. As the gears move, that part moves too.

Gears can turn each other because they have *teeth*. Look at the picture of the gears at the top of the page. Draw a line around some of the teeth.

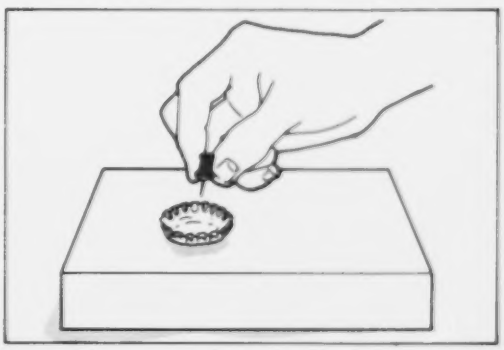
Now make a model of two gears, and see how they work. You'll need two bottle caps (the kind that are on soda bottles), two push pins, a hammer, and a block of soft wood (such as pine).



A gear can turn another gear.

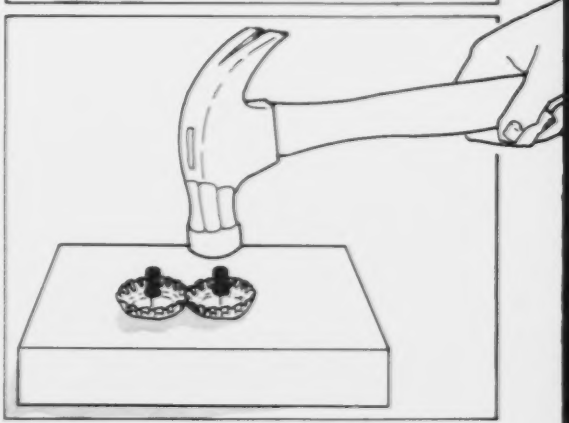
1

Put a bottle cap face down on the wood. Put a push pin in the middle of the cap, and hammer it into the wood.



2

Place the other bottle cap so it tightly touches the first one. Put the other push pin in the middle of the cap. Hammer it to the wood.



3

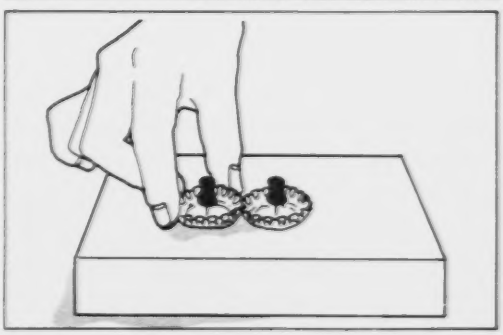
Turn a bottle cap. What happens?

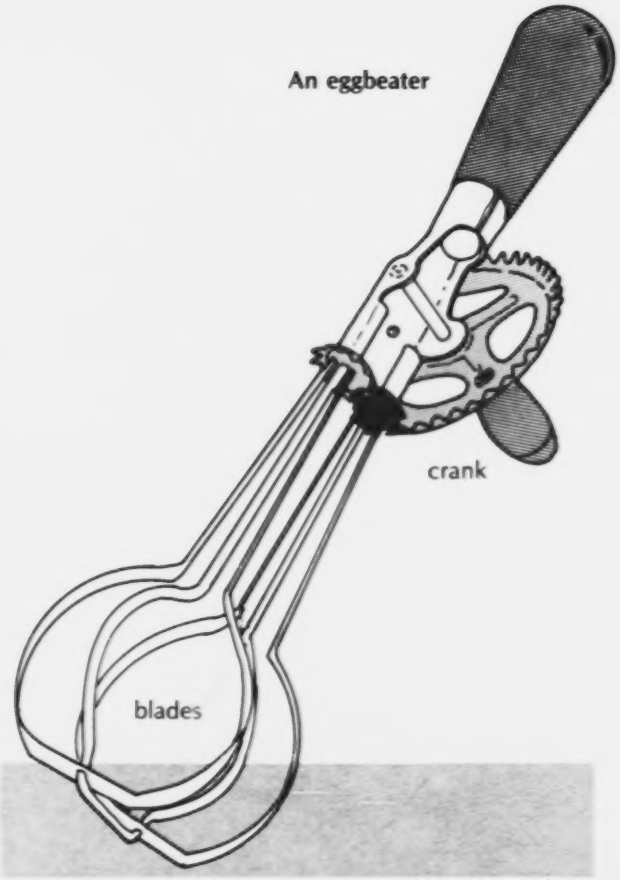
_____

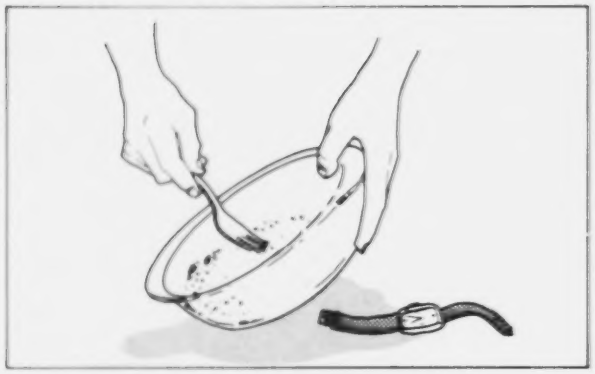
Right. The other bottle cap turns too. Why does it turn?

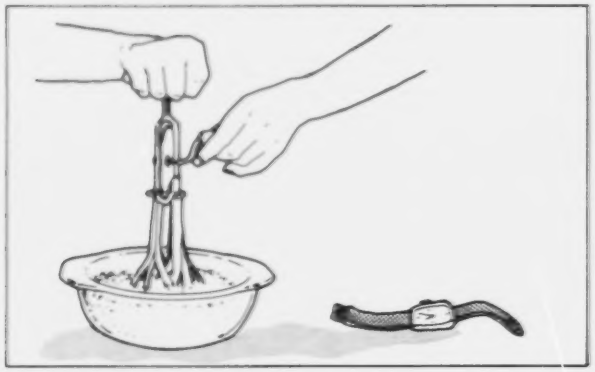
_____

_____









A Close Look at Gears

Gears move parts of machines. Gears also *control* how fast or slow parts move. You can see that with an eggbeater.

Look at the eggbeater above. It has a large gear and small gears. Draw a circle around each gear.

Now get an eggbeater like the one in the picture. Turn the large gear with the crank. What happens to the small gears next to it?

Right! The large gear turns the small gears.

A *blade* is attached to each small gear. The gears move those blades. The gears also let you turn the blades quickly or slowly. Try turning the crank so the blades move slowly. Then turn it faster, and even faster.

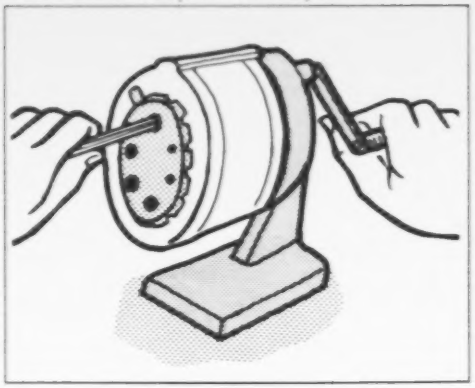
Now, see how the eggbeater can make work faster and easier for you. Get half a cup of whipping cream (or two egg whites), a fork, and a watch. Put the whipping cream in a bowl. Using the fork, beat the cream until it is stiff and fluffy. Look at your watch when you start and when you finish. How long does it take?

Get another half a cup of whipping cream, and put it in a bowl. Now, use the eggbeater to beat the cream. Time yourself. How much faster does it take?

Machine Choice

When you sharpen your pencil with a hand-turned pencil sharpener, you are using a wheel and axle. Look at a pencil sharpener like the one in the picture. Take off its case. Then look for these parts: pencil holder, cutting rollers, gears, handle.

A hand-turned pencil sharpener



1. Turn the handle. What happens to the other parts?

_____

_____

2. Which part of the pencil sharpener is the wheel? (Hint: It looks something like the spoke of a wheel.)

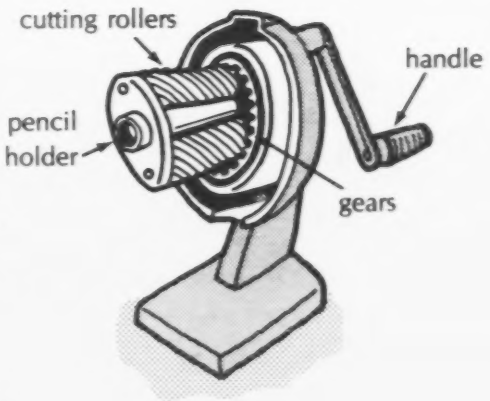
_____

_____

Why do you say it is the wheel?

_____

_____



3. Which part is the axle?

_____

Why do you say it is the axle?

_____

4. What causes the cutting rollers to move in a circle?

_____

5. What causes the cutting rollers to spin?

_____

6. Now put a pencil into the pencil holder. Turn the handle a few times. Explain how the parts work together to sharpen the pencil.

_____

_____

_____

_____

Check Yourself

Answer these questions. The page after each question shows where you can find the answer.

1. What kind of work can a wheel and axle help you do? (page 30)

   _____

   _____

2. Why does a wheel and axle make it easy to move things? (page 31)

   _____

   _____

3. What makes a gear turn another gear? (page 32)

   _____

   _____

4. Why are gears used? (page 33)

   _____

   _____

5. The picture shows three machines that have wheels and axles. One machine is circled. Circle the others.

Check These Out

1. Invite an auto mechanic to class. Ask him or her to speak about the different wheels and axles on a car.
2. Find pictures of different machines that have wheels and axles. Look in magazines and newspapers. Cut the pictures out and make a poster.
3. Get the model of gears that you made on page 32. Add more gears to it. Does each gear turn? Do they all turn the same way?
4. Here are some things you may want to find out:
   - What is *torque*?
   - What is a *windlass*? How does it help you do work?
   - What are some wheels and axles that you use for play and work?

Unit 6

The Pulley

Did you ever ride on a Ferris wheel? A simple machine makes the Ferris wheel turn. That same simple machine is used to raise and lower the huge tents at a circus. What's the machine? A **pulley**.

- What is a pulley like?
- How does it make work easier?
- How does it make other machines work?

You'll learn the answers in this unit.

Before You Start

You'll be using the science words below. Find out what they mean. Look them up in the Glossary. On the lines below, write what the words mean.

1. **groove** _____

_____

2. **pulley system** _____

_____

Belts, Ropes, and Pulleys

Picture this:

You're using a vacuum cleaner. But the roller brush isn't picking up dirt. So you turn the vacuum cleaner off and open it up. *Aha!* The belt that connects the roller brush to the motor is broken!

You get a new belt. Now, where do you put it? Look at the diagram. Draw where you think the belt should go.

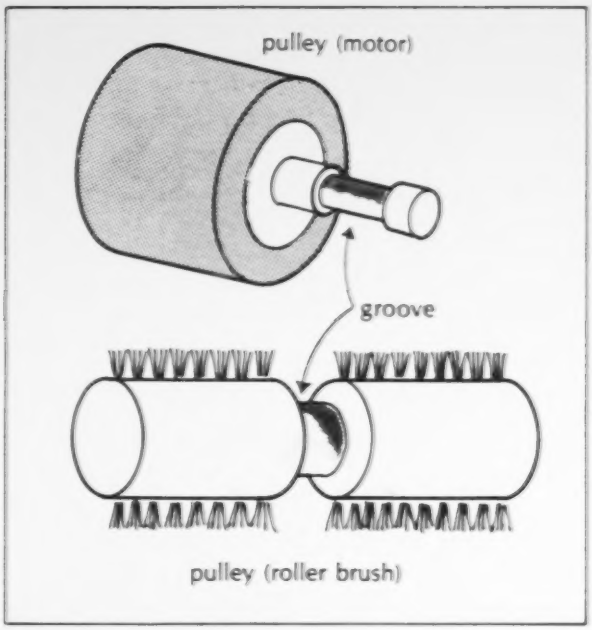
There's a certain kind of wheel on the motor. That wheel has a *groove*. The roller brush also has a groove. The wheel with the groove is a pulley. The brush with the groove is also a pulley.

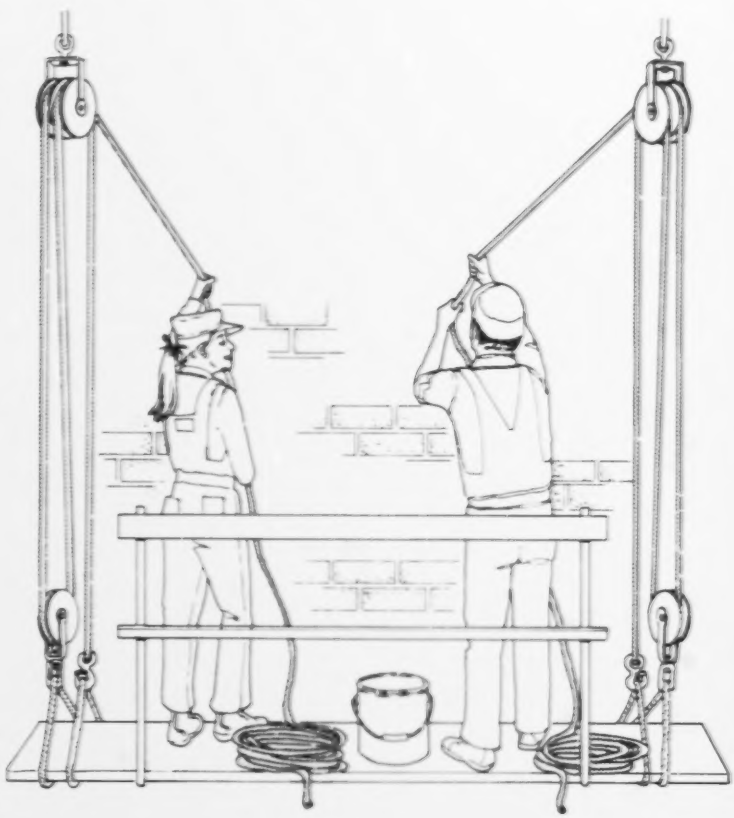
A pulley is a wheel with a groove around it. You put a belt or rope around the wheel. The groove keeps it on the wheel. You use pulleys to move things, like the brush in the vacuum cleaner.

You can also use a pulley to lift very heavy things to a very high place. Here's how: You tie one end of the rope to the thing you want to move. You pull the other end and up goes that thing.

When two or more pulleys are used, they make up a *pulley system*. Many different workers use rope and pulley systems. Those systems help them lift heavy objects. For instance, painters use pulley systems to lift themselves up tall buildings.

The two pulleys and the belt in the vacuum cleaner also make up a pulley system. Machines with moving parts often have pulley systems like that. Motors are attached to pulley systems inside those machines. What's one machine that has a motor attached to a pulley system?





Painters use pulley systems to lift themselves up sides of buildings.

Why Use More than One Pulley?

You learned about pulley systems. A pulley system is made up of two or more pulleys. Why do we use more than one pulley? Find out.

You'll need two strong tables. Put them about two feet apart. You'll also need:

- 15 feet of thin rope
- strong string
- two boards: 3 feet and 4 feet long
- three curtain pulleys
- some thick books (such as desk dictionaries)
- scissors

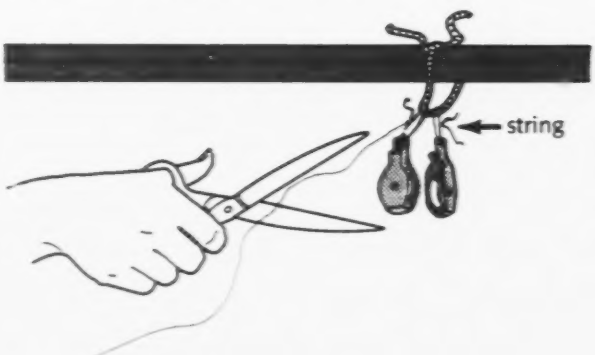
curtain pulley

1

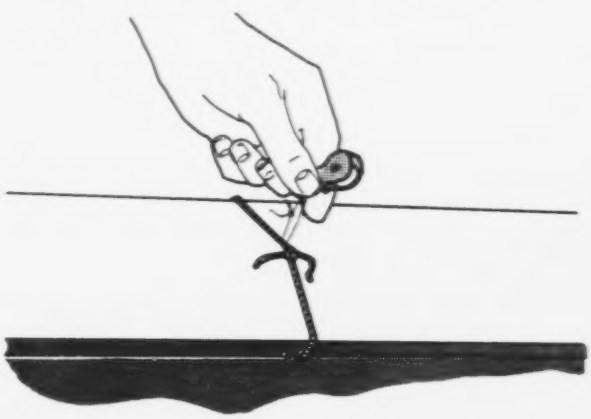
Lay the long board across the tables. Lay the short board on the floor, under the long board.

2

Cut some rope and tie it to the long board. Tie two pulleys to the rope.

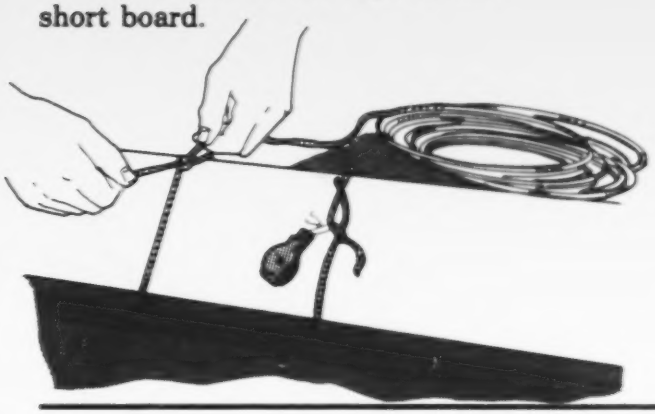


Cut more rope and tie it around the short board. Tie one pulley to that rope.



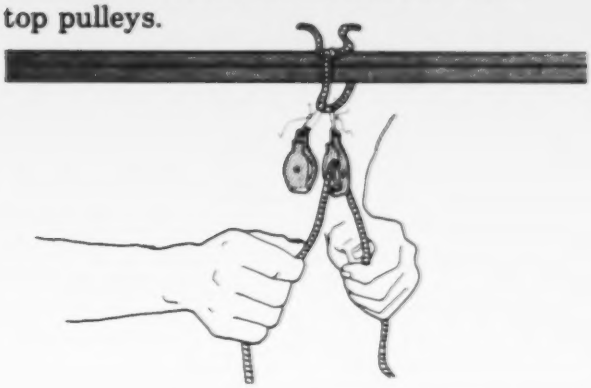
3

Tie one end of the rope to the short board.



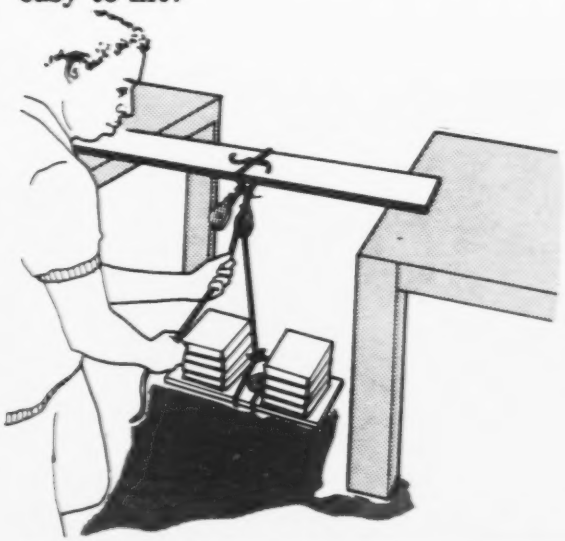
4

Loop the other end around one of the top pulleys.



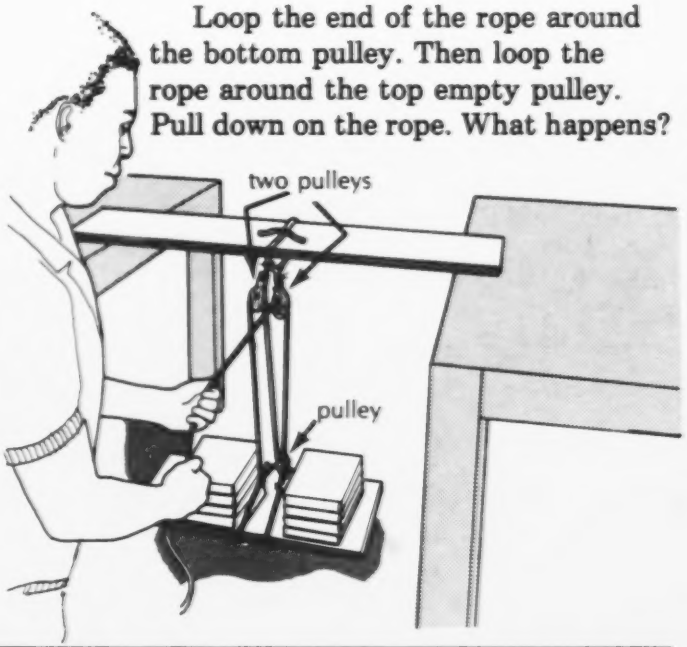
5

Put the books on the short board. Pull down on the rope. Is the board easy to lift?



6

Loop the end of the rope around the bottom pulley. Then loop the rope around the top empty pulley. Pull down on the rope. What happens?



What Happens?

1. What happens when you use one pulley?

   _____

2. What happens when you use three pulleys?

   _____

   _____

   _____

Moving Parts

Pulley systems are part of many machines. They are used to move parts of machines.

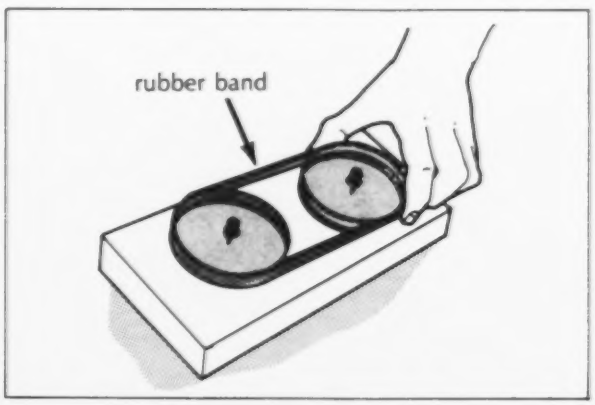
Make a model of a pulley system, and see how it works. You'll need these materials: a mayonnaise jar with its lid, a lid (such as from a mayonnaise jar), a 3-inch rubber band, two push pins, hammer, and a block of soft wood (such as pine).

1

Place the lids on the block of wood. They should be 1 inch apart. Hammer a push pin into the middle of each lid.

2

Loop the rubber band around the two lids. Turn one lid. What happens to the other lid?



_____

3

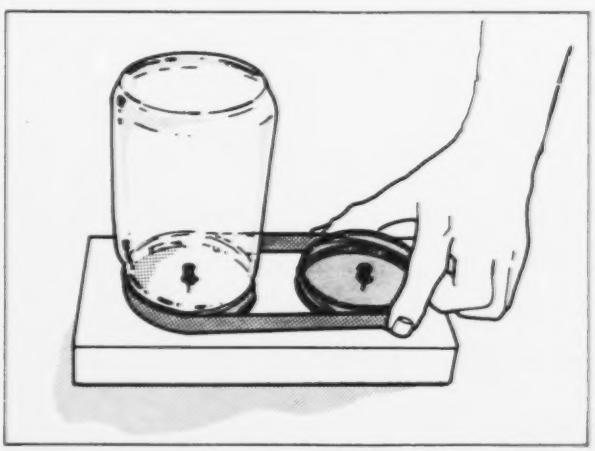
Screw the jar to its lid. If you turn the other lid, what do you think happens to the jar? Try it. What happens?

_____

That's right. The jar turns. Everytime that lid turns, the jar also turns.

A pulley system in a machine works in that way. A moving part is attached to one pulley. When the other pulley turns, the part moves.

Machines with parts move round and round in pulley systems. The escalator is an example. What other machine is like that?



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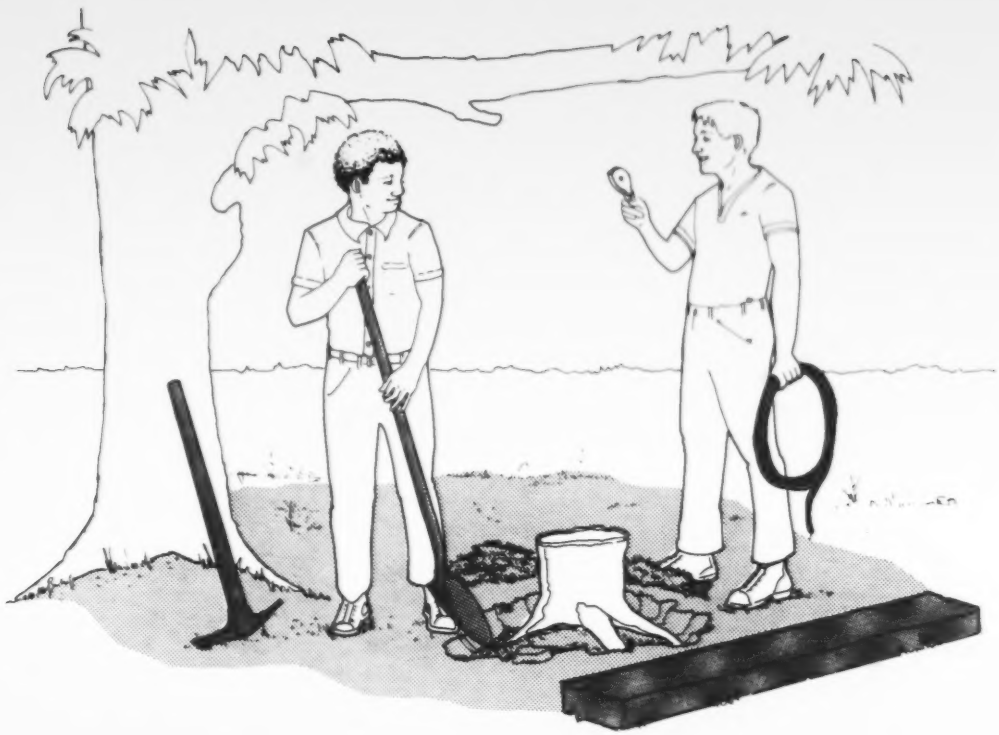


Machine Choice

Imagine this:

You and a friend are garden workers. You're taking out a small tree.

First you cut the tree down. You use an ax to do that. Then you and your friend start digging out the tree stump. But you need something to help you take it out.

Look at the pictures of different machines. Which machine (or machines) would you use?

_____

_____

_____

How would you use the machine (or machines)?

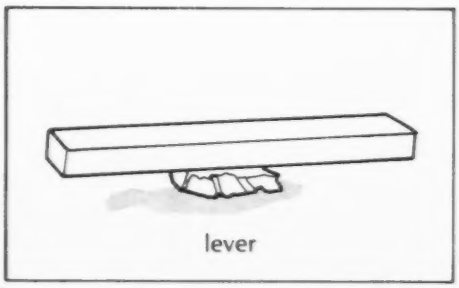
_____

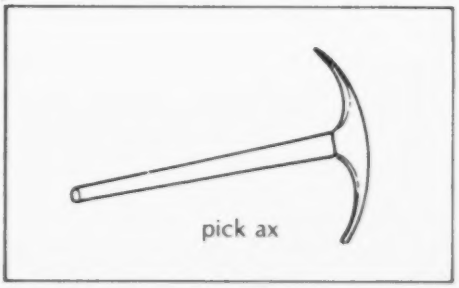
_____

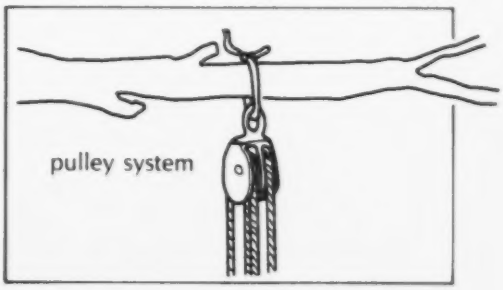
_____

_____

_____







Check Yourself

Answer these questions. The page after each question shows where you can find the answer.

1. What is a pulley? (page 37)

   _____

   _____

2. What is a pulley system? (page 37)

   _____

   _____

3. What happens when you add more pulleys to a pulley system? (page 39)

   _____

   _____

4. What do pulley systems do in machines? (page 40)

   _____

5. Look at the picture. It shows two pulley systems. One pulley system is circled. Find the other one and circle it.

Check These Out

1. A cannery is a factory that puts foods into cans. In some canneries, workers stand at *conveyor belts* and put foods into the cans. Find out what a conveyor belt is, and how pulley systems make it work. Give a report about them.
2. Visit a factory that uses conveyor belts.
3. Pulleys are part of film projectors. Look at a projector. Find where the pulleys are and what they do. Make a drawing that shows how the film projector works.
4. Look through magazines for pictures of machines that have pulley systems. Cut the pictures out and make a poster with them.
5. Here are some things you may want to find out:
   - What is a fixed pulley? A moveable pulley?
   - Where do you find pulleys on ships?
   - How do escalators work?
   - How do *elevators* work?

Unit 7

Using Machines

You learned about five simple machines. What are they?

_____

_____

_____

_____

_____

Simple machines can be used by themselves. They can also be put together to make other machines.

The pictures show two machines that are made up of two or more simple machines. Find the simple machines that make up each machine. Circle them in the picture. Then write the names of the simple machines that you found.

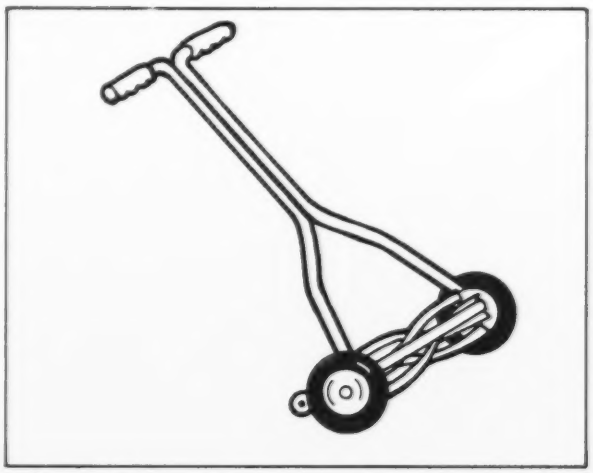
1. lawn mower

_____

_____

_____

_____



lawn mower

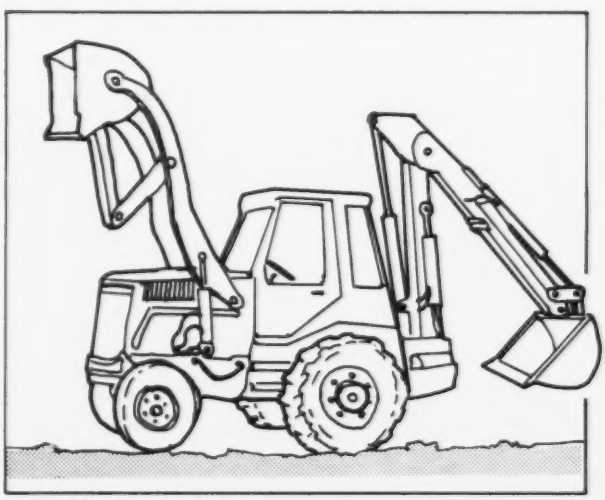
2. backhoe

_____

_____

_____

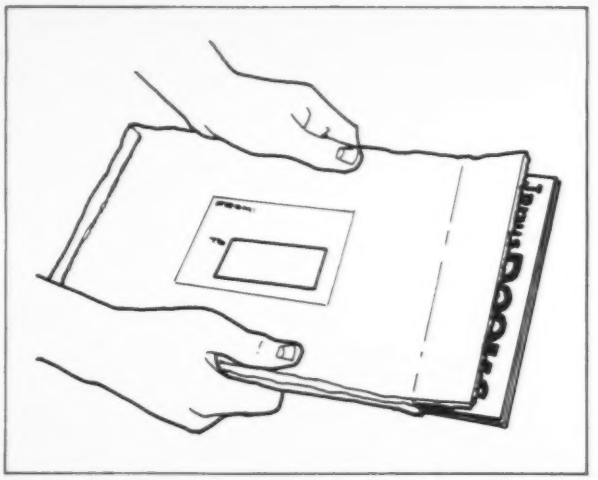
_____



backhoe

Working in a Warehouse

Suppose you work in a warehouse that stores and ships books. You do different kinds of work each day. On these pages, read about some of the work you do. Then decide what machine you'd use.



Opening Boxes, Packing Books

1. You are opening boxes. They are taped with heavy paper tape. The pictures on the right show what machines you could use to open them. Which one would you use?

   _____

   What simple machines are part of it?

   _____

   _____

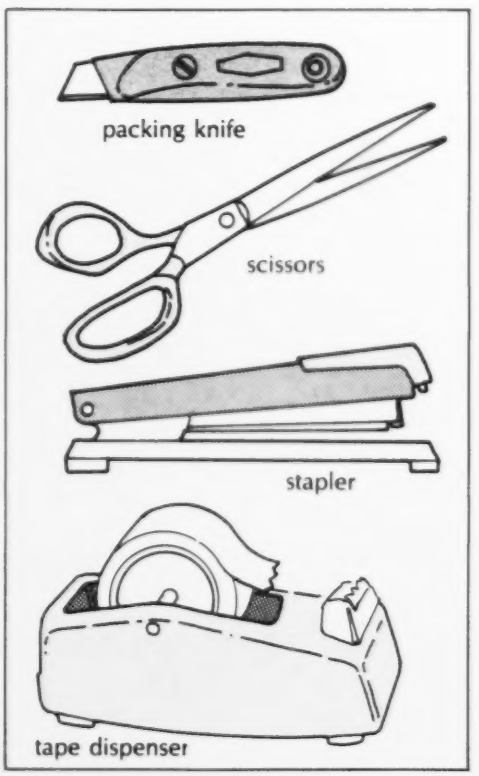
2. You pack books in bags. You must seal the bags tightly shut. Look at the pictures on the right. What machine would you use to seal the bags?

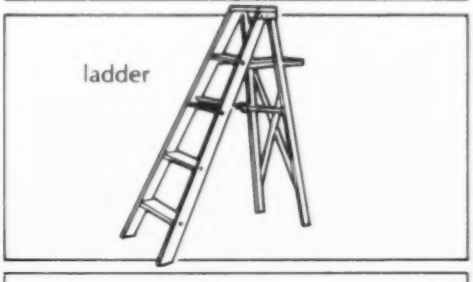
   _____

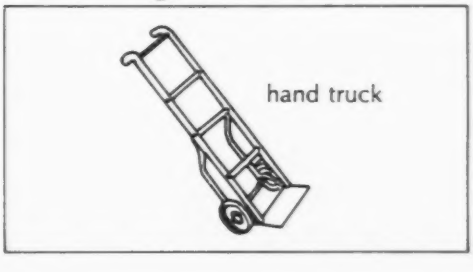
   What simple machines are part of it?

   _____

   _____







Putting Books Away

1. Your next job is to put boxes of books on shelves. The pictures on the left show the machines you could use. (If you're not sure what those machines do, look them up in the Glossary.) Suppose you put boxes on a shelf that's one foot above the ground. What machine would you use?

   _____

   What simple machines are part of it?

   _____

   _____

   _____

   _____

2. Sometimes you put very big and heavy boxes on shelves that are 15 feet high. What machine would you use to help you?

   _____

   What simple machines are part of it?

   _____

   _____

   _____

   _____

Show What You Learned

What's the Answer?

What simple machines help you do certain work? Write *inclined plane*, *wedge*, *lever*, *wheel and axle*, or *pulley*.

1. What helps you *push* or *pull* things up from the ground to a higher place?

   _____

2. What helps you move things that are tightly stuck? Or lift heavy things?

   _____

3. What helps you *lift* things up to a very high place?

   _____

4. What helps you cut, split, and make holes?

   _____

5. What turns in circles and helps you move things?

   _____

6. What simple machines increase force and make you stronger? Name three.

   _____

   _____

   _____

What's the Word?

Write the correct word for each meaning.

1. A push or pull

   F _____

2. When you move something from one place to another

   W _____

3. To put all of a force in one very small place.

   C _____

4. All machines are made of at least one of these

   S _____ M _____

5. One kind of inclined plane

   R _____

6. To make more

   I _____

Congratulations!

You've learned a lot about machines. You've learned:

- what all machines are made of;
- what the five simple machines are;
- how they each can help you do work; and
- many other important facts about machines.

Glossary

con cen trate To put all a force in one very small place.

con trol To make something go as fast or slow as you want.

force A push or pull.

fork lift A machine that's used to lift heavy things to very high places.

ful crum The part a lever moves on.

gear A kind of wheel and axle.

groove The part of a pulley that a rope or belt fits in.

hand truck A machine that's used to lift and move heavy things. It has two wheels.

in clined plane A simple machine. It helps you move things from the ground to a high place.

in crease To make more.

lad der A machine that helps you climb to a high place.

le ver A simple machine. It helps you move things that are tightly stuck. It also helps you lift heavy things.

ma chine Something that helps you work.

ob ject A thing.

pul ley A simple machine. It helps you lift and move things.

pul ley sys tem It is made up of two or more pulleys.

ramp One kind of inclined plane.

sim ple ma chine An inclined plane, wedge, lever, wheel and axle, and pulley.

slope The way an inclined plane slants.

split To push two sides of a thing apart. You use an ax to split wood.

steep Having a very high slant. The sides of a mountain are steep.

tool A small machine such as a hammer, saw, knife, and scissors.

wedge A simple machine. It helps you cut, split, and make holes.

wheel and ax le A simple machine. It helps you carry and move things from one place to another.

work To move something from one place to another.

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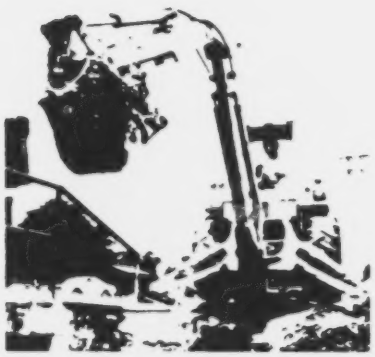
Machines



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